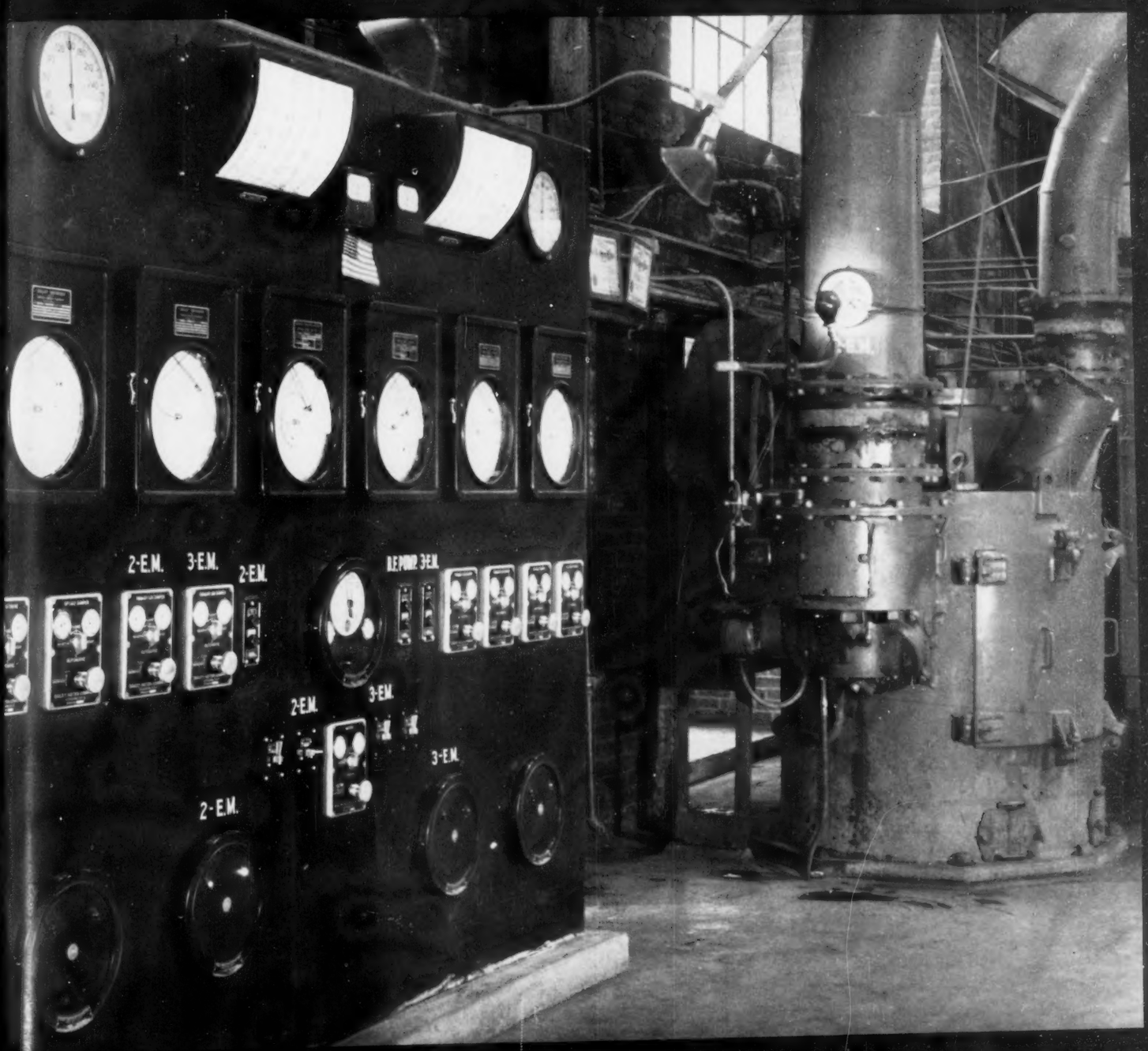
Instruments

THE MAGAZINE OF Measurement and Control

Vol. XIII
DEC. 1940
No. 12



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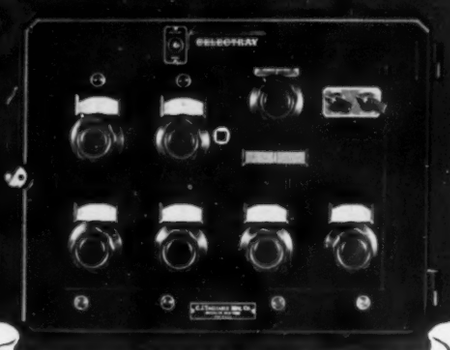
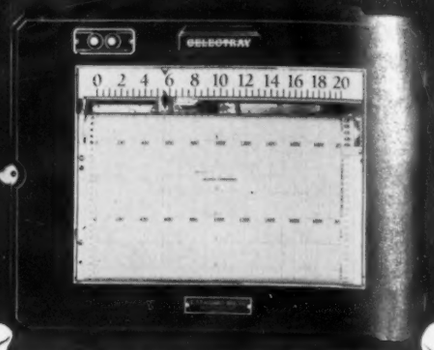
CELECTRAY RECORDER CONTROLLER
for Throttling Electric Heat

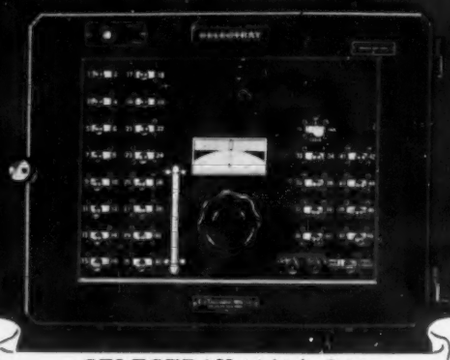


CELECTRAY
6-Point INDICATING CONTROLLER
Also made for 3, 4 and 5 Points



CELECTRAY RECORDER CONTROLLER
for Throttling Fuel Heat

CELECTRAY Single Point INDICATING
POTENTIOMETER CONTROLLER



CELECTRAY Multiple Point
MANUALLY BALCANCED INDICATOR

CELECTRAY Multiple Point
SELF-BALANCING INDICATOR

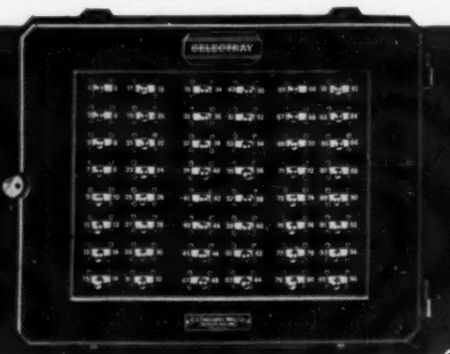
The CELECTRAY principle of potentiometric measurement and control of temperatures has been reduced to practice in many laboratory and industrial applications. Because, the most compelling feature of this notable line of Pyrometers is expressed in terms of their contribution to more precise and economical plant operation.

Today, a new CELECTRAY Controller is providing an economical means for throttling electric heat with no other equipment than is ordinarily used for on-and-off control. This new Controller has no dead zone, and holds a steady temperature without oscillation.

The TAG method of photoelectrically balancing a potentiometer or Wheatstone bridge means higher recording accuracy, increasing the value of CELECTRAY as a precise electrical instrument.

The CELECTRAY Pyrometers shown here include most of the newer models for indicating, recording and controlling. We urge you to get the whole story on these rugged modern instruments . . . learn what their matchless sensitivity, speed and adaptability can do for you in lowering operating expense and raising product uniformity.

CELECTRAY Vibration-Proof
INDICATING CONTROLLER



CELECTRAY 96-Point SWITCH BOX

CELECTRAY
Two-Point INDICATING
POTENTIOMETER CONTROLLER

C. J. TAGLIABUE MFG. CO.

Park & Nostrand Ave's., Brooklyn, N. Y.

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You Can Get **Not 1 but 5 Forms of Control** in the **NEW TAYLOR FULSCOPE CONTROLLER**

THE NEW Taylor Fulscope Controller is unique. It can *grow* in your plant. It can grow as your processing needs grow. At first your processing needs may be simple, so you install the simplest form of the new Fulscope. As time goes on, perhaps your production expands, and your processing operations become more demanding. You need a different controller. What to do? Buy another instrument? You don't need to! Another unit assembly may be added to or substituted in your basic Fulscope Controller. That converts it into the controller your progressing needs require. You see, merely by adding or substituting such unit assemblies in the drilled and tapped Fulscope cases, it's possible to expand the Fulscope Controller to give all types of process control—from simple *fixed high sensitivity*, through *adjustable sensitivity*, *adjustable sensitivity with automatic reset*, to *adjustable sensitivity with Pre-Act*, (Taylor's amazing new control effect based on rate of control-point deviation) and *adjustable sensitivity with automatic reset and Pre-Act*, the ultimate in process control. You may never need such advanced control, but Taylor has it if you want it. The new Taylor Fulscope Controller is industry's 5-in-1 controller for *all* kinds of process control.

There's a national need today for this astonishingly versatile, adaptable Fulscope Controller. Industry's biggest job is helping America prepare fast. You must be prepared to produce top quality at top speed. With this new Taylor Fulscope Controller in your plant, you *are* prepared. No other process controller is so completely new—none has been so completely redesigned (not just tinkered with)—no other is so easily adaptable to growing, changing processing needs. Your own preparedness program can well begin with the new Taylor Fulscope Controller.

Ask the Taylor man what the 5-in-1 features of the new Fulscope mean specifically to *you*. Find out about the recording and indicating types—for temperature, pressure, flow, and liquid level. Learn about the new Taylor Recorder, twin of the Taylor Fulscope Controller. *Now*—from Taylor Instrument Companies, Rochester, N. Y. Plant also in Toronto, Canada.

Not 1, but all these 5 Forms of Control Available in the NEW TAYLOR FULSCOPE CONTROLLER

Fixed High Sensitivity—Adjustable Sensitivity—Adjustable Sensitivity with Automatic Reset (in same case)—Adjustable Sensitivity with Taylor's unique Pre-Act effect Adjustable Sensitivity with Automatic Reset and Pre-Act

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BE PREPARED with TAYLOR INSTRUMENTS

Taylor

Indicating Recording Controlling

TEMPERATURE, PRESSURE, FLOW *and* LEVEL INSTRUMENTS

Chicago building SAVES $781 PER YEAR on fuel with "RANAREX"* CO_2 Indicator and Recorder!

As a direct result of installing a Ranarex CO_2 Indicator and Recorder, The Real Estate Corporation, Managers of the Times Building, Chicago, report *annual* savings of $781 on fuel—more than twice the purchase price of their Ranarex equipment.

H. EDSALL OLSON, President, writes: "We have in this building two hand-fired 200 horse-power marine-type boilers. Two years' operation under Ranarex has disclosed a saving of 146 tons of coal per year. Translated into dollars that means a saving of $781.10 per year."

LET RANAREX CUT *YOUR* FUEL COSTS, TOO!

It's easy to cut fuel costs with an all-mechanical Ranarex CO_2 Indicator and Recorder! You get readings almost instantly. You get them constantly—a continuous 24-hour record. No chemicals, orifices or fragile parts! Operates on lighting circuit. Get free booklet showing how well-known firms have saved up to 20% on fuel. Write to The Permutit Company, Dept. A8, 330 West 42nd Street, New York.

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*TRADEMARK REG. U. S. PAT. OFF.

Instruments
THE MAGAZINE OF MEASUREMENT and CONTROL

Vol. XIII DECEMBER 1940 No. 12

FRONT COVER: Control board for two 110,000 lb./hr. pulverized-coal-fired boilers at Libby-Owens-Ford Glass Co., Toledo, Ohio.
Courtesy Bailey Meter Co.

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Instruments

THE MAGAZINE OF *Measurement and Control*

M. F. BEHAR, Editor

Industrial Instrumentation Comes of Age

IN line with the long-standing policy set forth in last month's editorial, *Instruments* is happy to assign half a page to the announcement of an evening course in Industrial Instrumentation, given at Case School of Applied Science, which starts next February. After reading Professor Miller's tentative schedule (page 396) you will know as much about the details of this course as we do. Nevertheless it is safe to assert that this course owes its raison d'ètre to *Instruments*. Let's look at the record.

To the best of our knowledge this is the most elaborate course of lectures on Industrial Instrumentation ever announced by an engineering school—except of course last year's announcement of a course of fifty-six lectures at Carnegie Tech. That course had to be cancelled because the one who was to have been in charge fell ill before its start and was flat on his back for three months.

It may be remembered that in our April 1940 issue there was announced a *day* course in Industrial Instrumentation in the Department of Mechanical Engineering of the Oregon State College (Professor S. H. Graf in charge). For the convenience of those interested, we reprint here the seven main headings of the Oregon course:

1. Review of basic standards; 2. Elements used in measuring devices; 3. Industrial measuring instruments; 4. Process control; 5. Examples from industry; 6. Precision of measurement and control; 7. Calibration and maintenance.

Since the evening course which was to have been given at Carnegie Tech represented a study of the needs of this district's industries, we give its main headings:

1. General introduction; 2. Basic principles and generic properties; 3. Automatic control principles; 4. Automatic controller classes and characteristics; 5. Electrical instrument classes and characteristics; 6. Temperature; 7. Pressure; 8. Rate-of-flow; 9. Positive liquid and gas metering; 10. Gas and pH analysis; 11. Automatic combustion control.

Dr. Draper's now-famous M.I.T. instrument course is perhaps more aeronautical than industrial. Interested readers may "sample" it from the article by him and Dr. Schliestett in our May 1939 issue.

Searching the files of *Instruments*, we find that the first announcement of an engineering school instrumentation course to which we gave space (Jan. 1934 issue) was a day course at Columbia University:

A course in instruments is the first laboratory course given to our Mechanical Engineering students. On account of the short time allotted to this subject they can do little more than study instrument principles . . . new curriculum will include a revised course in Instrument Laboratory, followed by a one-term, three-hour-per-week lecture course on Instruments and Controls. These two courses will be required for Mechanical Engineering students and open to others properly qualified . . . will be largely qualitative. A more advanced course will . . . deal with quantitative analysis of existing apparatus.—H. L. PARR, Prof. of Mech. Eng.

The first fairly-complete outline of the scope of industrial instrumentation was in the form of a three-page table which appeared in the November 1930 issue of *Instruments*. We had prepared that table at the request of *Instruments* (that was before we became editor) and in our introduction to it we explained:

. . . The scientific instrument of yesterday is the industrial instrument of today. . . . Today there are no industrial instruments pertaining to hardness, all of them being testing instruments. Tomorrow . . . we may witness the production of bar and sheet stock whose hardness is controlled not in the laboratory but automatically during production . . . Inasmuch as I wished to avoid the rôle of dictator and remain a reporter, this tabulation not only covered known industrial instruments but allowed for coming developments in the way of industrializing present-day laboratory testing and scientific instruments.

In 1927, when industrial automatic controllers were written up for the Fourteenth Edition of the *Encyclopaedia Britannica*, "the powers that were" did not like the word Instrumentation. They said it was a musical term. They re-titled our article "Regulation, Automatic." They were not alone: *we* were alone! In fact, even the before-1927 contributors to "The Engineers' Handbook of Industrial Instruments" would probably have declined to aid such a fantastic project as a "Manual of Instrumentation." In those days there was only a vision and a prophecy—the prophecy being universally met by scoffing . . . although it has come true, for today there *are* instrumentation societies and there *are* instrumentation courses!

Anyway, it doesn't matter much. The main thing is that the dreams could not have come true if there had been in another city another vision—a practical vision—if there had not appeared in January 1928 in the City of Pittsburgh, the first issue of a magazine then called *Instruments Industrial—Scientific*, which name became, beginning with the January 1932 issue, the one you see at the top of this page. And now, one hundred and fifty-six consecutive issues of THE magazine of measurement and control have come out. To say that each issue has "enriched American civilization," and all that sort of thing, would sound extravagant. However, as *Instruments* concludes its thirteenth year of service, attention may be called to the fact that there have been tremendous advances in the fields to which it is devoted—not only in the establishment of instrumentation courses but:

—in the useful applications of instruments, meters, automatic controllers, inspection and testing devices, etc., throughout industry;

—in their diversification, standardization and quality;

—in the formulation of the theories underlying proper selection and correct application of these products;

—in "the recognition of Instrumentation as a distinct branch of engineering and as a distinct field of scientific management"—even by some groups jealously antagonistic in the past (but now climbing on the bandwagon);

—in the publication of authoritative texts on the several distinct branches of Instrumentation;

—in the organization and management of instrument departments;

—in the training of instrument apprentices, instrument engineers, etc.;

—in the influence and standing of instrument men;

—in the economic status of all instrument men, from young instrument apprentices to instrument-minded high executives whose titles do not include the word "instrument";

—and in the manifold blessings to American civilization thereby brought about.

THE COUNTER READS

0	0	1	5	6

and thereby registers the end of the thirteenth year of *Instruments*' service to users of measurement and control devices—to all of whom we wish a Merry Christmas and a HAPPY NEW YEAR

BAILEY METER CONTROL SYSTEM

The Mark of

Effective Control

Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.

Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.

Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

G-3

BAILEY METER COMPANY

1041 Ivanhoe Rd., Cleveland, Ohio

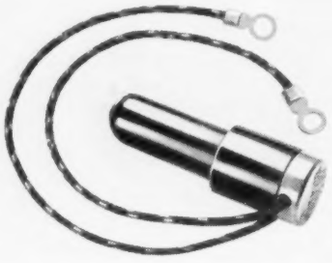
THE MONTH'S NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control.

When writing to manufacturers directly, please mention this department as your source of information. Or write to Information Section, Instruments Publishing Company.

Mercury Switches

Two new unbreakable mercury switches, "No. A-5M" and No. A-10Z," can carry greater currents than maker's regular switches with the same dimensions. Stand-



ard "A-5" is rated for 200 watts a.c. lamp load at an operating speed not to exceed 20 times per minute; new "A-5M" (same dimensions as A-5) withstood 750,000 operations on a 500 watt a.c. lamp load at 5 times per minute 24 hours a day; also 50,000 operations on a 1,000-watt d.c. lamp load at 25 times per minute. Performance of the A-10Z is equally impressive when compared to a standard A-10 identical in dimensions. The A-5M is adapted to snap-acting mechanisms, as well as tilt action; can be used in many applications which formerly required the A-10 (10-amp. switch.) Similarly, the A-10Z can be used in many applications where formerly the capacity of the A-10 was not enough and the A-20 (20-amp. switch) was required.—*Durakool, Inc., Elkhart, Indiana.*

Circuit-calculation Device for Equalizer Design

The McProud "Quadget" is intended to simplify the design of constant impedance equalizers, specifically for 500-ohm circuits. However, it is possible to adapt the values given to circuits of any other impedance. On the face of the "Quadget" are charts showing the transmission characteristics of the equalizers and suppressors for which values are given. Also, the configuration of the various networks are shown, along with the values. Place the desired resonant frequency adjacent to the letter indicating the shape of curve required, and the values are shown for the elements of the network. These values are designed for curves of the shapes shown when the pad loss is 10db. For other pad losses, the constant k_1 shown on the reverse along with the resistor values for the required pads are used as shown. For circuits of impedances other than 500 ohms, conversions may be made in accordance with the information supplied on the face of the device. All values for inductances are in henries; for condensers, in microfarads. — *Norman B. Neely, 5334 Hollywood Blvd., Hollywood, Calif.*

Frequency Meter

New vibration frequency meter weighs 8 oz., is no larger than a slide-rule, but can indicate what frequencies between 500 and 20,000 c.p.m. are present in a vibrating

body. Employing the vibrating-reed principle, it consists of a thin spring-steel vibrator clamped at one end between a set of steel rollers. A knurled knob connected to the rollers permits their rotation, and moves the steel reed in or out, changing its frequency. A sliding pointer on the back end of the reed indicates the vibrating frequency which is read on a scale on the frame of the instrument. To use the meter, its head is held against the vibrating body and the adjusting knob rotated until the reed vibrates at maximum amplitude. If more than one vibrating frequency exists, there will be a point of maximum amplitude for each, and vibrations in differing planes may be detected by changing the axis of the meter. The meter will indicate a vibration whose double amplitude is 0.0001" or greater. It can measure harmonies of basic vibration frequencies. Although not designed to measure the amount of vibration, it may be used as a rough indicator of its magnitude. It is said that the meter will stand all normal rough treatment without losing its calibration. Because all moving parts are direct connected, i.e., no gears or gearing employed, backlash is non-existent in the adjusting knob, and the indicating scale. — *Westinghouse Elec. & Mfg. Co., Research Products Dept., Radio Div., Baltimore, Md.*

Sodium Lamp Controller

A Novalux controller has been announced for use in experimental, laboratory, or spectacular lighting applications of the 10,000-lumen, Type NA-9 sodium lamp. It is available for multiple-circuit a-c. operation only. Composed of a compact cast-iron case equipped with simple brackets, the controller has a terminal board readily accessible, with an "on" and "off" control switch; other operations are automatic. The controller comes equipped with 15 feet of 4-conductor rubber-covered cable to permit operation of the sodium lamp at distances up to 15 feet from the controller. It is suitable for indoor or outdoor use.—*General Electric Co., Schenectady, N. Y.*

UP TO

3,666,666 OHMS per VOLT!

Negligible Voltmeter Loading
No Ohmmeter Resetting

NEW RCA JUNIOR VOLTOHMYST

Here is a D.C. *Electronic* push-pull Volt-Ohmmeter, using the famous Rider VoltOhmyst circuit—*plus* a convenient isolated A.C. 1000 ohms-per-volt Rectifier-type Voltmeter—all at a price scarcely higher than the price of an ordinary volt-ohmmeter!

Constant input resistance of 11,000,000 ohms on D.C. Voltmeter ranges of 0-3, 10, 30, 100, 300, 1000 volts—permits checking A.V.C. and A.F.C. voltages, and oscillator grid-bias voltages under actual operating conditions *with the signal present,* through an isolating 1-megohm signal-tracing probe! Sensitivity is as high as 3,666,666 ohms per volt!

As an ohmmeter, too, this new RCA test instrument gives accurate resistance-readings . . . from 0.1 ohms to *1000 megohms,* in 6 Decade steps. No zero resetting is necessary when changing scales. See the RCA Junior VoltOhmyst at your RCA Distributor's.

Over 380,000,000 RCA Radio Tubes have been purchased by radio users . . . in tubes as in test equipment and accessories it pays to go RCA All the Way.

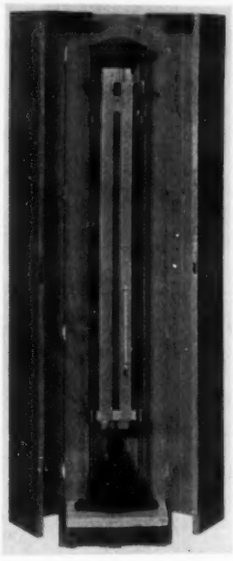
RCA VICTOR PREFERRED TYPE RADIO TUBES — For Finer Radio Performance

RCA Test Equipment

RCA Manufacturing Co., Inc., Camden, N. J.
A Service of the Radio Corporation of America

Altimeter Testing Barometer

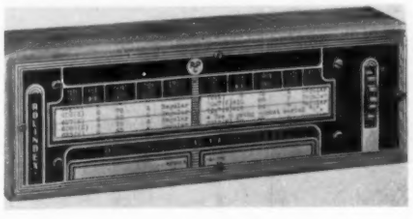
New "No. 35" altimeter testing barometer consists of a mercury tube, two silvered brass scales, and a cistern with a suitable hose connection. The left-hand



scale is graduated in tenths of an inch from 6.50″ to 31.50″ with sliding vernier reading to 0.01″; the right-hand scale is blank but mounted thereon in the lower portion is a 7¼″ stem graduated and figured thermometer ranging from 10° to 120°F. in single degrees, figured every 10°. Scales are adjustable to ± 500 feet. Instrument is permanently mounted in a mahogany case with a center-opening double door. To facilitate easy reading, there is mounted therein an opal glass reflector the full distance of the scales.—*Henry J. Green, 1191 Bedford Ave., Brooklyn, N. Y.*

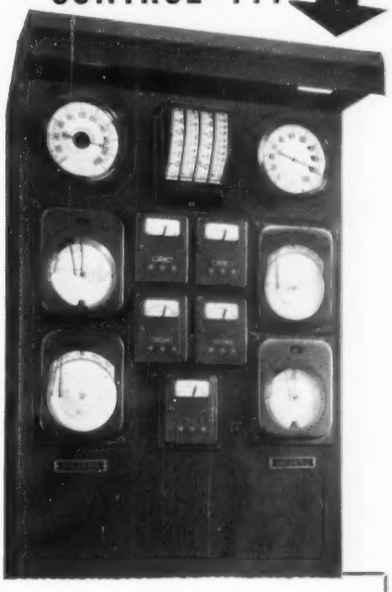
Roll-type Chart for Attaching to Testers

Incorporation of a roll-type tube chart as a built-in feature of some new tube testers increases their appearance, speeds up tube testing and obviates the use of sepa-



rate charts. These same advantages can be provided for many older tube testers by new "Rolindex" tube chart which, mounted in its own 11″ × 3¾″ × 3″ hardwood case, can be easily attached to existing tube-testing equipment. Unit consists of a mechanical movement driving the roller chart and actuated by a knurled disk projecting edgewise through the front panel. Set into this panel is a window of transparent plastic with a horizontal hairline engraved across its center to guide the eye across the columns of test-control settings. Chart roll is renewable: up-to-date charts will be available from R.C.P. as new tube types require. Numerous charts are now available. "Rolindex" is supplied in two models: Model 102 with internal illumination, Model 101 without.—*Radio City Products Corp., 88 Park Place, New York City.*

HERE'S Hays CENTRALIZED COMBUSTION CONTROL . . .



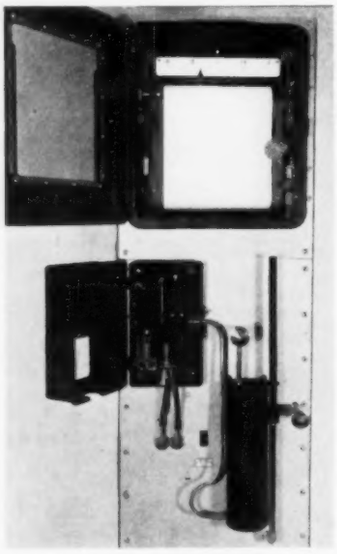
HAYS is the one truly CENTRALIZED control system—All of the control and measuring instruments are contained in one panel. Here is concentrated all information necessary for an intelligent understanding of what is going on inside the furnace, boiler and steam lines. And from this central panel the entire control system or any individual part of it may be operated manually.

Hays Centralized Combustion Control is offered through capable engineering organizations located in all principal cities of the U.S.A. and Canada. Correspondence is invited. Send for our 40-page catalog. Write to 925 Eighth Avenue, Michigan City, Indiana.

The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROLS
MICHIGAN CITY, INDIANA, U.S.A.

Dissolved Oxygen Recorder

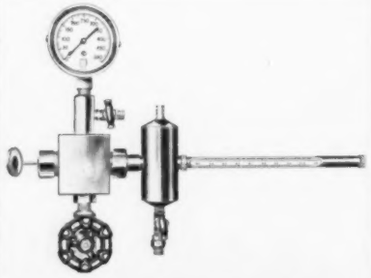
Designed for use by operators of large steam plants, new Cambridge Dissolved Oxygen Recorder has a sensitivity such that dissolved oxygen in feed water can



be measured to one part in 400,000,000. It is completely automatic and provides a continuous indication and record of dissolved oxygen entering the boiler. It has a range of 0 to 1 part of dissolved oxygen per 1,000,000 parts of water. It records full scale upon a chart 10" wide. Readings of 0.01 part of dissolved oxygen per 1,000,000 parts of water may be readily determined since they will scale 0.1" on the chart. Readings of 0.003 parts will scale nearly 1/32" on the chart. Operation of the instrument's metering unit is based upon the thermal conductivity principle wherein four platinum spirals forming four arms of a Wheatstone bridge are employed. Water to be analyzed enters a cooler-regulator where it is reduced in temperature and maintained at approximately 85°F. A constant head device maintains the correct flow of water through the scrubbing tower of the analyzer unit. Hydrogen is generated in the electrolytic cell and flows to the scrubbing tower where it comes into intimate contact with the sample water. The water dissolves some of the hydrogen and gives up part of its oxygen. The resultant mixture of gases diffuses to the meter block which contains the measuring elements: four platinum spirals connected in the form of a Wheatstone bridge which are heated to a definite value by the current flowing through them. Two of the spirals are exposed to the sample gas and two are permanently sealed with saturated hydrogen. When pure saturated hydrogen surrounds the exposed spirals the bridge is in balance and no deflection of the recorder occurs, thereby indicating zero oxygen. When the exposed spirals are surrounded by a mixture of hydrogen and oxygen their temperature will increase due to the lower thermal conductivity of the mixture. This causes a change in resistance of the spirals with a consequent unbalance of the bridge circuit. The deflection of the recorder is, therefore, proportional to the concentration of dissolved oxygen in the sample water passing through the scrubbing tower.—*Cambridge Instrument Co., Inc., 3732 Grand Central Terminal, New York City.*

Automatic Timer

Principal features of new Bacon Automatic Timer are: mercury-to-mercury contacts enclosed in unbreakable metal tubes; one moving part; self-starting and self-oiling clock movement. Time ranges are available in hours, minutes or seconds.—*Emra D. Bacon, 4513 Brooklyn Ave., Cleveland, Ohio.*



DEW POINT TESTER

FOR HIGH PRESSURE GASES

Bureau of Mines Type

Simple to operate and accurate in results.

This apparatus for the accurate determination of the dew point of gases under pressure was developed by the Bureau of Mines and is described in its Report of Investigations 3399.

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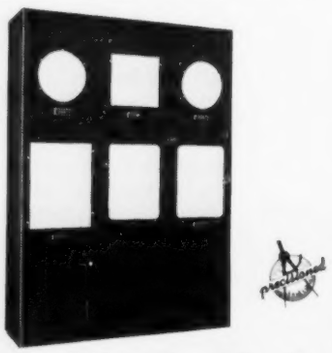

STEEL PANELS

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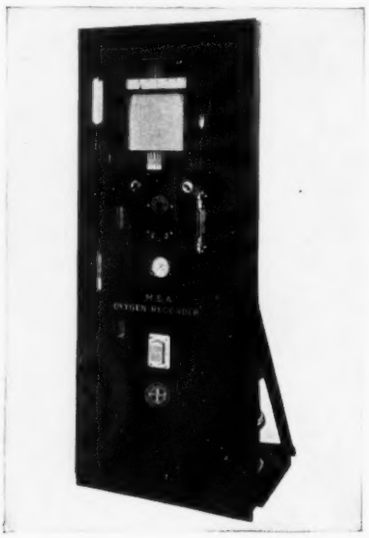
Oxygen Recorder

New "M.S.A. Oxygen Recorder," available completely assembled on a 7-ft. high steel panel, is for measuring and recording oxygen in other gases, and is said to



be the only instrument of its type made in America. It measures oxygen concentrations from 0 to 20.8% and can be calibrated for any range desired within these limits. Recorder is principally a voltaic cell, made of cast hard rubber, containing an electrolytic solution which is a strong reducing agent, and two electrodes of pure copper. One electrode, in the form of a bar, is completely immersed in the electrolyte; the second, in the form of a ring, slowly revolves with approximately half of its periphery submerged in the electrolytic solution. As the surface of the copper electrode revolves out of the solution, oxygen in the sample reacts with the copper to form copper oxide. With continued rotation the copper oxide is submerged in the solution and then a potential is set up between the copper oxide and the negative copper electrode. This potential is not influenced by the rate of sample flow and is proportional to the amount of oxygen in the sample. Other advantages claimed are: all conductors carrying sample and solution are of hard rubber; clear plastics are used instead of glass where transparency is required; construction of the electrical control box excludes corrosive gases; electrical parts and conductors are enclosed in explosion-proof fittings; CO_2 and other acid gases can be removed from interference with operation, when necessary, by a caustic scrubber.—*Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh, Pa.*

Hydraulic Booster Pump

A new motor-driven hydraulic pump capable of developing pressures up to 6,000 lbs./in.^{2} is especially applicable for use in creating high test pressures for catalytic hydrogenation work, for determining the bursting strengths of cylinders, spheres, etc., for operating high-pressure and hydraulic intensifiers, and for determining the effects of high pressures and their sudden release on various materials. It consists essentially of a geared-head motor (for operation on 115 or 230 volts a-c. or d-c.), reservoir and compression chamber, mounted on a substantial cast iron base. Theoretical displacement per hour, 553 cu. in. Working volume of the reservoir, 1300 ml.; actual volume 3000 ml. Working and actual volumes of the compression chamber, 1300 ml. Tested to 9000 lbs./in.^{2}.—*American Instrument Company, Silver Spring, Md.*

Vacuum-tube Voltmeter

New "Model 62" operates on 115-v, 60-cycle supply, weighs approx. 6 lbs., is accurate to 2% of full-scale on each range. (1) D-c. Voltmeter: Stabilized, balanced,

degenerative amplifiers eliminate zero drift—no change of zero with range selection. High input resistance—less than 10-8 amp. grid current on all ranges. Provision for reversal of polarity—convenient in taking discriminator curves, etc. Linear scale calibration on all d-c. ranges. (2) A-c. Voltmeter: Balanced diode circuit eliminating zero drift on a-c. ranges. Low-loss, low capacity probe designed for minimum loading at high frequencies. Blocking condenser to separate a-c. from d-c. potentials applied to probe. On a-c. the instrument is a peak voltmeter calibrated to read r.m.s. values of a sine wave or 71% of the peak value of a complex wave. Pushbutton Selection of Five Ranges: 1, 3, 10, 30, 100 volts full scale either a-c. or d-c.—*Measurements Corpn., Boonton, N. J.*

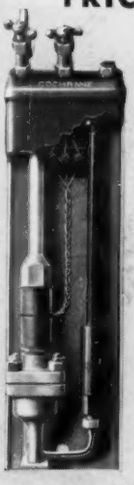
Mounting Strips

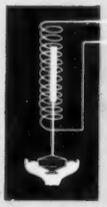
Facilitating the use in multiple of signal-lights, toggle-switches, and push buttons, new standardized mounting strips said to have wide application in the signal, con-

trol, and general annunciator fields, are not unlike those used in the construction of telephone switchboards, etc. They are of stainless steel, rippled finish, and have beveled ends. A strip is furnished with all devices mounted on it ready to install and place in service. Strips are available in three lengths, to contain 2, 3 or 5 units per strip. There is a designation strip to match each length. One strip may contain any combination of devices, and the strips may be banked together to an unlimited degree. All of the devices are for service on voltages up to 220 volts. Each strip is mounted with two screws directly to machines, panels, etc.—*H. R. Kirkland Co., Morristown, N. J.*

Check these points of Cochrane's

"FRICTION-FREE" Electrical Transmission





In a measuring instrument high accuracy is achieved (1) by eliminating friction as far as possible (2) by applying ample power to overcome *inherent* friction.

In the Cochrane "Friction-Free" Electric Flow Meter both requirements are met.

STARTS WITH "FRICTION-FREE" TRANSMITTER

In the transmitter of the Cochrane Meter there are no stuffing boxes, bearings, linkages or gears—just a free moving float positioning a core within the transmitter coils.

RELIEVES MEASURING CIRCUIT OF ALL WORK

In the receiver of the Cochrane Meter high power from an external source overcomes the frictional load of pen, indicator and integrator, relieving the float and measuring circuit of all work.

ENDS WITH HIGH AND EQUAL POWER THROUGHOUT ENTIRE SCALE

The Cochrane Electric Flow Meter employs the NULL method of measurement, universally recognized as the most accurate means of measuring a force or quantity. By it, the float merely acts as a pilot, through a sensitive galvanometer, for an external source of power achieving high and equal power throughout the entire scale.

Because of this, Cochrane accuracy is a certainty, and can be guaranteed within exact limits at varying loads.

AND THIS GUARANTEE

Within ½% of absolute accuracy on full load.
Within ¾% when operated at 75% of full load.
Within 1% when operated between 0 and full load on daily runs averaging 45% of full load.

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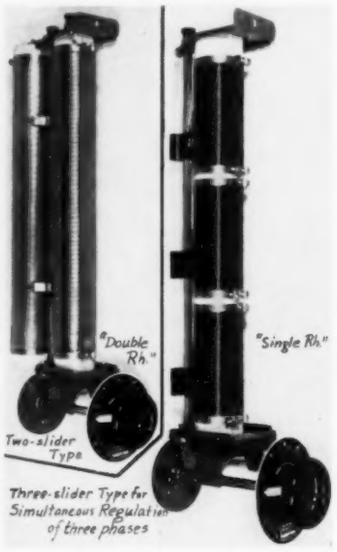
FLOW METERS

Rotary-drive Rheostats for Switchboard Mounting

Several new designs, all for switchboard mounting, are announced of the lubricated-contact rheostats (full description of basic features: *Instruments*, Dec. 1939, page 316).



Angle of rotation of new rotary drive is 330°. Pointer indicates position of contact brush which is actuated by steel-cable system entirely free from back-lash. Illustration conveys idea of possibilities of combining sections in series, in parallel, etc., more than fifty styles being available. It may be noted that dividing the sliding path into two halves (left) permits using a small driving wheel taking no more space than width of rheostat.—*Rex Rheostat Co., 37 W. 20th St., New York City.*

Circuit-calculating Device for Attenuator Design

The "McProud Padget" is a slide-rule-like device for determining the resistors required for attenuators without resorting to extended calculations. Additional information is provided useful to the audio engineer, experimenter, or radio amateur. Resistor values are shown for pads of various configurations in 500 ohm circuits. For other line impedances, Z1, multiply all values shown by Z1/500. In the case of the bridged "T" pad, the 500-ohm resistances must be replaced with resistances equal to Z1. For unsymmetrical pads between impedances Z1 and Z2, not shown on the reverse side, the values P1 and P2 and the formulae may be used to calculate the proper resistances for R7, R8, and R9. K is the voltage ratio corresponding to the loss in decibels. "Grid Pot" shows values to be used in the grid circuit of a vacuum tube. On the reverse side, values are given for unsymmetrical pads between differing impedances. Power in watts applies to zero level of 0.006 watts. Volts across 500 ohms enables any rectifier-type AC voltmeter to be used as a power level indicator. For measuring distortion, or harmonic content, a common method is to adjust the output of the amplifier to the desired level with a constant frequency; insert a high pass filter; and measure amplification necessary, N db, to bring output up to the level obtained before insertion of filter. With the slide at a value corresponding to N db, read the distortion directly in percentage in the opening marked "Harmonic Content." For values of N greater than shown on the slide, subtract 20 db from N and divide the distortion shown by 10.—*Norman B. Neely, 5334 Hollywood Blvd., Hollywood, Calif.*

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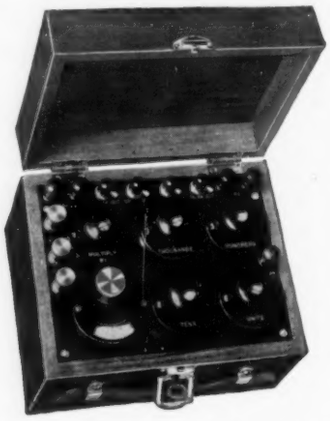
WHEATSTONE BRIDGE



A high grade instrument for measuring resistances from a fraction of an ohm to 10 megohms. Contains a 4-dial rheostat, ratio dial, galvanometer and battery, all enclosed in a substantial walnut case. Nine coils per dial. Accuracy .1%. Built to endure.

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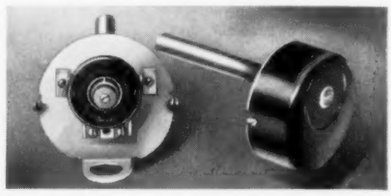
Air Thermoswitch

New Thermoswitch illustrated comprises, basically, a Fenwal Cartridge Thermoswitch (see *Instruments*, July 1938, page 176 for initial announcement and diagram) to



which has been attached a junction box, thereby providing facility for attaching BX cable or conduit to a terminal block within a protective cover. It is impossible on the Cartridge Thermoswitch to make use of any kind of protective cable over the lead wires or to incorporate a graduated dial and knob; Air Thermoswitch provides ready means of using both. Field of application has been widened; there is added the entire field of ventilation and air-conditioning. New Air Thermoswitches are catalogued as Regular (R) when the contacts open on an increase in temperature; Inverse (I) when the contacts open on a decrease of temperature. Adjustment is made by removing cover and turning metal knob. Standard, adjustment change 125°F. per full turn of knob; other temperature adjustments can be furnished. The adjustable operating range is—50° to 400°F. Contact rating, 10 amperes 115 volts; 5 amperes 230 volts a.c. ¾ hp—iph 115-230 volts a.c.—*Fenwal Inc., Ashland, Mass.*

Outdoor-temperature-compensated Thermostat System

Chief use of new "Remote Bulb Econostat" is to regulate the heating system in apartment and office buildings, hotels, factories, etc. Intended for those installations

which cannot be satisfactorily controlled from a single thermostat, it regulates the heating system of the building directly from the outdoor temperature by supplying the heat at intervals. It maintains the desired indoor temperature by varying the "heat on" periods in accordance with outdoor temperature changes. Thus, the heat supplied to the building is in proportion to the heat loss from the building and is not dependent upon the temperature in any particular room. The "Econostat" is readily installed in either new or existing buildings, and will control any type of heating system whether fired by a gas or oil burner, stoker, or central station steam.—*Barber-Colman Co., Rockford, Ill.*

Industrial Pyrometry

Fourth instalment of new and completely revised edition of "Temperature Measurement and Control." We regret that circumstances beyond our control prevented fulfilling the promise made in this space last month: "The subject of pyrometry will be concluded in the December instalment." Two other chapters on pyrometry will follow. Some developments to be described therein are so recent that details are not available as we go to press.

By M. F. BEHAR

CHAPTER XI

VISUAL OPTICAL PYROMETRY

1. Modern Divisions of Optical Pyrometry.

Originally, optics was the science of light—of visible light. Since 1800, discoveries gradually revealed new regions of the spectrum of radiant energy—on both sides of the visible spectrum. Instrumental eyes were invented, capable of seeing farther and farther into the infrared; farther and farther into the ultraviolet. Some of these instrumental eyes can respond to waves a thousand times longer than red-light waves; others can respond to waves a million times shorter than violet-light waves. Even instruments utilizing the wave nature of electrons have become so common that recent years have witnessed the publication of books on electron optics. Optical pyrometry has benefited, of course, from these discoveries, so that it no longer is limited to methods employing the human eye. Whence the need of new names.

Where to find the new names? Not in dictionaries and encyclopædias: their compilers have not caught up because they wait for scientific authorities to advise them. But so rapid have been the advances in industrial "optical" pyrometry that the scientific societies and institutions which represent the highest authorities on this branch of physical science have not yet decided how to christen the new babies.

Some of these babies, by the way, are so far beyond infancy that they are on the payrolls of various high-temperature industries—under trade names given them by their manufacturers. What shall we (you, reader, and the present writer) call them in order that we may take up in the most convenient order (most convenient to us both) the numerous ramifications of modern industrial optical pyrometry?

Let's not be hasty. Let's not call them all "photoelectric." That would only complicate matters, as will be brought out later.

Here's a lucky circumstance: the word *Visual* still refers to the human eye; and there's little chance that it will ever be applied to the new babies. So let us apply it to all of the "old" types of optical pyrometers—and also to all future types of optical pyrometers depending on the human eye. This makes a convenient starting point. We can take up the Visual Optical pyrometers in this chapter and, in the next chapter, the new babies which are still unnamed. But now it becomes easy to name them: in the first place they are optical pyrometers (not total-radiation). In the second place they are non-visual; in other words they measure automatically; in one word they are autometric.

Hold on! Don't skip to the next chapter, no matter how fond you are of automatic methods, for the visual methods still hold the place of honor in optical pyrometry—and probably will hold it until 1950 or 1960 . . . perhaps for another century.

The fact is that the area of optical pyrometry became an athletic arena when the autometric instruments entered the various competitive events. Not only did the visuals improve their performance as a team but they split up into a number of teams competing with one another and setting new records for accuracy and general usefulness. At this writing (1940) there are more classes, types and varieties of visual optical pyrometers on the industrial market than there were of all pyrometers before the First World War (when the basic laws of optical pyrometry had already been formulated long enough for inventors to devise ten times as many different instruments as were available then).

Also, there is more *to* visual optical pyrometry than there was as recently as the nineteen-twenties when new types and varieties appeared at a greater rate than before or since. Thus, a comprehensive treatment of all classes and types would be a lengthy undertaking—which will not be attempted here; but a comprehensive treatment of all major subjects and of a selection of minor topics would fill a lengthy book—which could only be produced with the aid of financial backing from a wealthy institution, government department or individual. The only fairly exhaustive treatment of visual optical pyrometry (not a word about photocells except in the Introduction which explains that they "pertain to photometry, not pyrometry") is the famous *Traité de Pyrométrie Optique* by Gustave Ribaud, Director of the Pyrometric Laboratory of the Baron Edmond de Rothschild Foundation. This volume of nearly five hundred pages has about as many words as Gone With the Wind. It represents ten years of work by a staff of scientists and research assistants endowed by a French millionaire who in 1919 built a laboratory which he hoped would give his native land pyrometric research facilities on a par with those of the Bureau of Standards in Washington or of the Reichsanstalt in Berlin. Well, this *Traité de Pyrométrie Optique* has about twice as many bibliographical references as it has pages—and the papers referred to would overflow the proverbial five-foot shelf. Moreover, Ribaud's book is dated 1931 and is largely devoted to what might today be called "classical" visual optical pyrometry. A collection of the literature on *all* branches of visual optical pyrometry up to 1940 would probably overflow *two* five-foot book-shelves.

2. How to Grasp the Subject Without Knowing Mathematics.

To mention that the literature would overflow a ten-foot shelf isn't telling the whole story: We must add that it is printed in more than nine languages (Dutch, Japanese, Norwegian and other foreign workers made contributions since 1930). We must add also that most of it is mathematical.

No living man has read all these works. Talented men (mostly women, rather) who understand the languages and the mathematics, are employed as technical librarians and are kept busy reporting on other subjects. There's little likelihood of a book like Ribaud's ever coming out again, even if another benefactor like the Baron de Rothschild were to donate his fortune.

Nobody knows all about visual optical pyrometry. Even the greatest of the scientists are specialists.

Cheer up! It is precisely *because* of this huge accumulation of scientific data, including super-high mathematics, that the "average" industrial pyrometrist, who is not a mathematician, has at his disposal today a choice of reliable instruments, and a wealth of reference tables (some of them supplied by instrument manufacturers), which make it possible for him to measure high temperatures with the greatest of ease.

And with the highest accuracy?

In general, yes. The answer depends, however, on numerous factors: The instrument must be suited to the particular class of "body" or "surface" as will be explained later; the instrument must be clean and in good adjustment at the time of measurement; the observer must use it correctly; and finally the conditions must be right. This last proviso simply means the absence of sources of error—but as a rule the user will have learned to watch out for them: In other words, routine industrial measurements can be made with as fine a degree of accuracy as is obtained in any other branch of industrial instrumentation.

Routine measurements on *known* sources, with carefully-maintained instruments—such is the secret of the consist-

ently accurate results one hears bragged about at engineering conventions and other gatherings of technicians from various high-temperature industries. Moreover, after attending such meetings for some fifteen years, one must come to the conclusion that not only were the applications standardized, not only were the conditions uniform from day to day, but the applications and conditions were always such as to permit the use of the most highly perfected type of visual optical pyrometer, namely, the disappearing-filament monochromatic-light type. *That*, gentlemen, is not Pyrometry with a capital P.

To call it pure luck, however, would not be right, either.

Nevertheless, the element of luck plays a part in modern industrial pyrometry, because the exact values of emittances and other conditions can never be foretold when a new application arises. The element of luck plays a part also whenever any instrument is purchased for taking the temperatures of several different sources. This is particularly true when a general-purpose instrument is purchased—no matter what its type. Therefore, the user of *any* optical pyrometer *should*, and the user of a general-purpose optical pyrometer *must*, have some knowledge of the science which he applies.

This science can be boiled down into several mathematical formulas. Only a mathematical physicist would find them sufficient mental equipment to start with. You, the reader for whom this book is meant, are not a mathematical physicist.

As promised a few paragraphs back, however, you need not have had mathematical training to become a first rate pyrometrist.

Visual optical pyrometry is the measurement of temperature by eye. That's what is was centuries ago before pyrometers were invented; that's what it is today. Our pyrometers help our eyes, so that we can measure within a few degrees whereas our forefathers did not even know the difference between heat and degree of heat. But the unimpachable evidence of old sword blades and other results of successful temperature control by eye proves that our forefathers could in some cases reproduce temperatures within 20 or 50 degrees.

Only the most skilled men could reproduce processing temperatures by eye. They had to have the gift—just as only a Michelangelo could at a moment's notice take a piece of chalk and draw a nearly-perfect circle upon a wall. In short, they were artists.

The art began to be a science with the gradual development of the Scale of Temperature, as narrated in Chapter I. A skilled ironsmith could connect his memory scale of color temperatures and brightness temperatures with the numerical scale of science and, therefore, when he wrote to a brother ironsmith that a certain process should be carried on at "3200 degrees on Fahrenheit's scale," this second worker would know how "white" and "bright" to run his furnace. The closeness of that knowledge would amaze many of today's youngsters who never came in personal contact with these old-time artisans.

The scientific explanation is already known to the reader: The brightness of an incandescent body varies from 15 to 25 times as fast as its absolute temperature, depending on the material and surface of the body, on the temperature range at which the process is carried on, etc. Therefore, an error of estimation which would be called huge when one estimates the weight of a package, or the speed of a runner, or the length of a bar, would become a relatively small error in terms of temperature.

An important relation—that between color and temperature—contributed to making a science out of the old art. Dull red, cherry red, orange, straw, etc., began to have quantitative meanings even when the instrument was the unaided eye. The scientific reason has been made apparent in Section 2 of the preceding chapter, where the main facts about the blackbody laws were set forth. It is obvious that the color change is most pronounced at temperatures between 1000 and 3000 degrees Fahrenheit: from the first visible red to the temperatures at which most bodies begin to appear white.

The next step in the reduction of the art to a science is to take advantage of the simultaneous color shift and brightness increase—by merely using a piece of colored glass. This is an important step forward because it ties in *radiant* energy and *luminous* energy. Without such a tie-up, there could be no such thing as visual optical pyrometry.

Another great step forward was the idea of *matching* brightnesses—whether in the sense of "white" or red—instead of estimating them in absolute terms. The accuracy could be enormously increased, particuarly if the observer could look through some sort of a telescope in which the field of view was divided so that he would see the image of the unknown source in one half and the image of a standard source in the other half. That kind of an instrument is known as a visual-match photometer. Even an untrained human eye can match the two halves of the field of view to one percent, whereas brightness memory and color memory —even of an artist—are erratic.

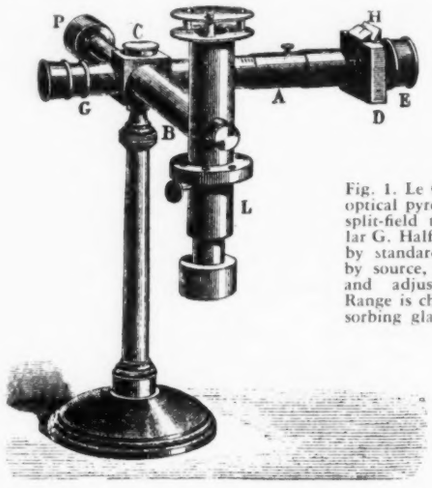


Fig. 1. Le Châtelier's photometric optical pyrometer. Observer views split-field through red-glass ocular G. Half of field is illuminated by standard lamp L; other half by source, through object-lens E and adjustable diaphragm D. Range is changed by inserting absorbing glass at E. *(Ribaud)*

It is interesting to note that in 1863, twenty-one years before the Stefan-Boltzmann law, thirty-three years before the Wien laws, Becquerel propounded the general principles of monochromatic pyrometry—matching the intensity of red light from the furnace, or forging, or molten-metal stream, against the intensity of red light from a standard source. The obstacle was that there was, at that time, not a single reliable method of measuring high temperatures in order to proivde the required standard sources.

(Extrapolate by a wedge method? Of course the scientists tried that, back in the seventies, when the science of photometry was well on its way, but the errors were actually greater than those of the unaided eye of an experienced melter. The wedge could not be perfected as a correctly-graduated temperature-measuring device until the concepts of the graybody and of the gray medium were fixed—and these concepts could not be imagined until the laws of the blackbody and their relation to the normal human eye were thoroughly worked out early in the twentieth century.)

So it was not until the development of rare-metal thermocouples that standard sources could be made available for realizing the idea conceived 'way back in 1863. It was around 1890 that Le Châtelier perfected his platinum and platinum-rhodium couple; and he lost no time in designing the first practical optical pyrometer (Fig. 1). This was in 1892, four years before Wien formulated his laws. Therefore, at that time, no one knew exactly how fast the intensity of red light increased with increasing temperature.

Le Châtelier, however, made it possible to "calibrate" his supposedly "monochromatic" optical pyrometer in terms of supposedly "true" temperatures of supposedly "blackbody" sources up to near the softening point of his platinum and alloy wires—which was high enough for nearly all metallurgical industry requirements. The visual "emissivity" properties of actual materials at high temperatures began to be studied on a "quantitative" basis. "Correction" tables began to be distributed to industrial users of Le Châtelier's instruments.

That was the beginning of optical pyrometry. It could have been gradually refined by cut-and-try methods, but there were fundamental obstacles to be overcome. Some of these obstacles are indicated by the words in quotation marks in the foregoing paragraph. They could not be overcome until—

—until (1) the portrait of blackbody radiation (Sec. 2 of Chapter X) became accurately known,

—until (2) this set of exact figures was tied up to another body of exact data on Light and Visibility,

—until (3) the transmission properties of various media became exactly known,

—and until (4) the emission properties of various materials and surfaces were named, listed and charted.

This last-mentioned work (see Sec. 3, Ch. X) is still under way: it never will be finished.

Let us return to the beginnings of visual optical pyrometry and mention another invention. Actually, it was born at the turn of the century—four years after Wien announced his laws, but its development owes as much to the four "untils" mentioned above as does the development of the Le Châtelier class, so we may consider that both classes were conceived before the formulation of the radiation laws.

When electric lamps had become fairly well standardized, Holborn and Kurlbaum in Germany, and Morse in the United States, simultaneously and independently conceived the idea of doing away with the optical-instrument parts of a divided-field photometer, by simply looking through a red glass

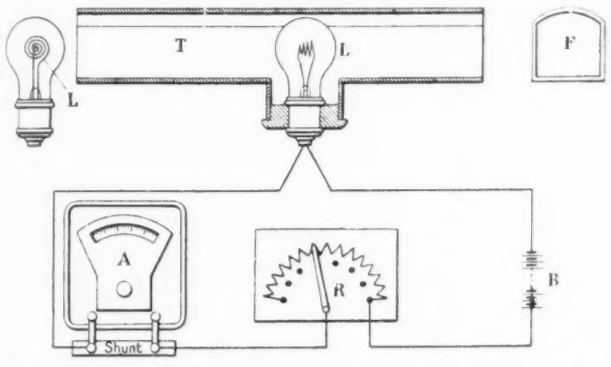


Fig. 2. Schematic diagram of Morse's disappearing filament optical pyrometer. *(Ribaud)*

close to the eye, and through a carbon-filament lamp, *at* the furnace or other source. The filament is seen as a line crossing the furnace peephole or the ingot, or the molten-metal stream. Fig. 2 shows that simple idea—the basic principle of the majority of visual pyrometers in use today. This made possible a different matching method: Le Châtelier's pyrometer included a standard lamp (a delicate scientific device in 1892) and the photometric match was made by cutting down the luminous flux from the source by means of a diaphragm (*D* in Fig. 1) to which the temperature scale was attached. In the disappearing-filament pyrometer, this could have been done (and it was done in later designs) but from the start the German and American inventors decided to vary the lamp current (by rheostat *R*, Fig. 2) until the filament "disappeared" against the background of the source, and then reading the temperature on ammeter *A*.

Differences in matching methods as well as in basic ideas led to modified types and later to refinements of all designs.

At this point it may be well to illustrate the disappearing-filament idea. Fig. 3 does not show photographs taken through Morse's original model: it shows three photographs taken through the Leeds & Northrup Morse type instrument.*

There is another type of monochromatic visual pyrometers: the polarizing type, so called because the brightness of the image of the source is cut down by rotating a Nicol prism until it matches the brightness of the image of a standard lamp.

*This instrument has been superseded by a new type, described in Section 4, in which a straight filament crosses the field of view. However, Fig. 3 remains an excellent pictoral presentation of the disappearing-filament idea.

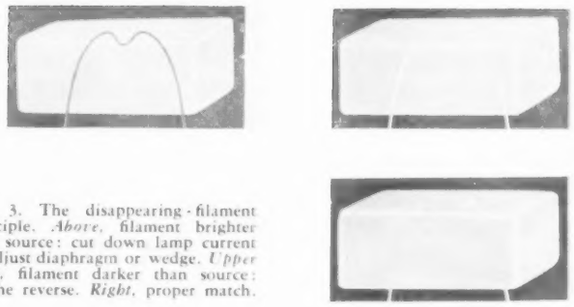


Fig. 3. The disappearing-filament principle. *Above*, filament brighter than source: cut down lamp current or adjust diaphragm or wedge. *Upper right*, filament darker than source: do the reverse. *Right*, proper match.

These and other types constitute the brightness-matching category. Only a few types have "survived" in this country in that they are favored by American pyrometrists.

Another broad category of visual pyrometers is represented by color pyrometers. It includes various classes, utilizing different principles of color temperature measurements. All of these principles, however, are themselves based on the blackbody radiation laws whereby not only the intensities of all frequencies are exactly known but also the *ratios* of intensities of any two frequencies such as blue and red, green and red, etc. If perfect colored glasses, gelatins, plastics, etc., were available, these instruments would become more popular, for their construction is generally simple and some of them are vest-pocket size. The color ratio is determined in various ways by moving the two filters (and sometimes a third "gray" filter) in relation to one another.

The "extinction" class belongs both in the "brightness" category and in the "color" category. One popular type comprises a glass or dyed gelatin screen which transmits more blue and red than the intervening colors of the visible spectrum. This screen is denser at one end than at the other. The observer slides it back and forth until he finds the spot (or region) where he barely sees the source. An even simpler type in the extinction-wedge class consists of a green wedge: the green is not spectrally pure, so that a red-hot source can be seen through the clearer end, a yellow-hot source through the middle, and only a dazzling-white source through the denser end. The simplest type is a "gray" or neutral or achromatic wedge—or rather an approximation of this irrealizable ideal material.

The variable-color-ratio pyrometers and the fixed-color-ratio extinction-wedge pyrometers are sometimes claimed to have a theoretical advantage over brightness-matching pyrometers, namely that corrections for the emittances of actual surfaces are theoretically negligible. This is not true.

It may be seen that visual pyrometers are difficult to classify. The following table is incomplete and perhaps scientifically faulty but it has been constructed to serve as a guide to the types in use.

Division	*Class*	*Type*
Brightness	Photometer 1. Equality field 2. Contrast field 3. Flicker Etc. photometrically	Variable distance Variable diaphragm Absorbing wedge Rotating sector Rotating polarizer
	Disappearing-filament 1. Ammeter 2. Potentiometer Etc. electrically	Variable current Variable diaphragm Absorbing wedge Rotating sector
Color	Extinction of total luminous flux	"Gray" wedge
	Extinction of most-visible color	"Green" wedge
	Color ratio	Two colored wedges do. + absorbing wedge

3. Temperature Measurement Essentials.

The aim of the foregoing section was to introduce, in non-technical and non-mathematical terms, all main subjects and a few subordinate topics. There will now be given a few essentials and a few suggestions for collateral reading.

Of prime importance are the *blackbody laws*. The ultimate reference standard against which precision visual pyrometers are calibrated is not a material body but *radiant energy* emitted through a small orifice from a uniform-temperature enclosure. Section 2 of the preceding chapter should therefore be considered as forming an essential part of this chapter.

For precision work, a calibrating department should if possible be equipped with a reliable blackbody source. Several forms are on the market. Perhaps the best form within the budget of a fairly large plant where optical pyrometry is extremely important is that described in *Bu. of Stds. Research Paper 325* (1931) by Wensel and associates. Fig. 4 is a diagram of its essentials—the induction-furnace windings not being shown.

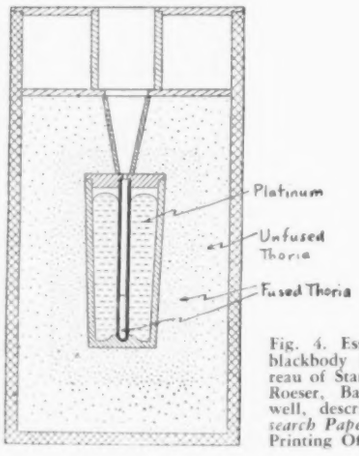


Fig. 4. Essential portion of blackbody developed at Bureau of Standards by Wensel, Roeser, Barbrow and Caldwell, described in their *Research Paper No. 253* (Gov't Printing Office, 5 cents).

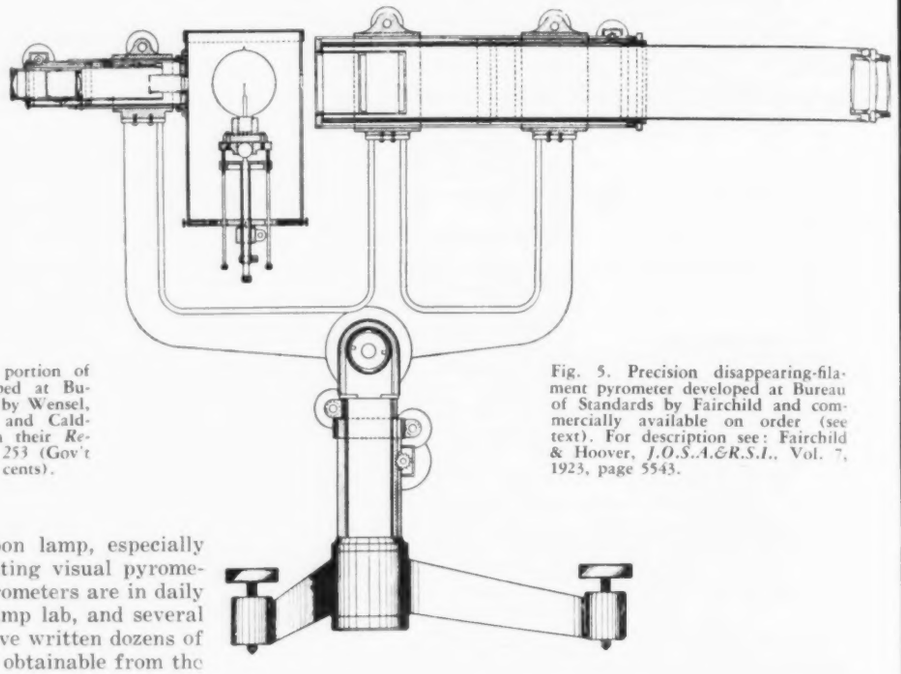


Fig. 5. Precision disappearing-filament pyrometer developed at Bureau of Standards by Fairchild and commercially available on order (see text). For description see: Fairchild & Hoover, *J.O.S.A.&R.S.I.*, Vol. ", 1923, page 5543.

At least one standard tungsten-ribbon lamp, especially designed and manufactured for calibrating visual pyrometers, is the absolute minimum where pyrometers are in daily use. Forsythe and Worthing at GE's lamp lab, and several workers at the Bureau of Standards, have written dozens of papers on this subject. These lamps are obtainable from the Bureau.

A precision optical pyrometer, in spite of its being delicate (merely transportable rather than portable) finds many uses not only in the calibrating room but wherever it can be set up without danger of injury. Fig. 5 is a sectional view of Fairchild's design as used at the National Bureau of Standards since about 1918. A number have been made for various industries by Bureau of Standards mechanics (working spare time) and by the American Instrument Co. The gap at the right of the comparison-lamp housing in Fig. 5 is for a rotating sector—one assigned to the pyrometer or one borrowed from a photometer bench whenever necessary. For measuring the lamp current, a direct-deflection ammeter would not be accurate enough, so a potentiometer is considered an essential part of a precision visual pyrometer.

Even a brief discussion of standards must not fail to mention the oft-forgotten "standard" inside most types of industrial visual pyrometers: the comparison lamp. Recent years have witnessed improvements in these lamps, the newer "box" forms being designed and constructed especially for this service, with inclined flat windows as well as with numerous other "features" all aimed at enhancing the accuracy of *temperature* measurements. With modern lamps this accuracy now depends on the related instrument factors. Thus, pyrometers of the current-measuring types can be "accurate to one degree" if the current can be measured to 0.1%.

Optical pyrometry shares with radiation pyrometry the requirement that the source must emit a continuous spectrum; it differs from radiation pyrometry in that the receiver is "selective." The criterion for applying the adjective "selective" is that the receiver does not respond according to the Stefan-Boltzmann fourth-power law. In general, the power is higher than the fourth. It never is constant, except in the hypothetical case of a receiver automatically selecting the peak-energy wave-length interval: shifting toward the higher frequencies as the temperature rises (and vice versa) in which case the power would be the fifth. In all other cases, where the center of gravity of the receiver's curve remains fixed—except for the slight temperature coefficients of colored glasses, etc.—*the power varies*. Inspection of the distribution curve discloses at a glance that the most rapid rise is in the region at the left of the peak-energy wave-length. But this peak-energy wave-length is inversely proportional to the absolute temperature. It follows that the response of any highly selective receiver, no matter where its center of gravity is located, will vary over the range of temperatures which it is designed to measure. Thus a nearly-monochromatic receiver with its center of gravity at 0.65μ (red light) responds most rapidly to temperatures in the industrial range; around 8000°F. its response is the fifth power; at higher temperatures its response becomes less than the fifth power.

Fig. 6 shows the basis of monchromatic optical pyrometry —whether visual or autometric: the reason why a monochromatic receiver can be calibrated in degrees of blackbody temperature.

A receiver may consist of a slightly-selective or even blackbody receiver-proper (the sensitive element) plus a more-or-less monochromatic screen or other selector. Thus the combination of a blackened thermopile receiver and a monochromator is the most selective "optical pyrometer"—though its use is in spectrometry rather than in pyrometry.

Only the monochromator (or any spectroscope arranged to provide the desired spectral purity) makes possible ideally sharp selection. The great majority of receivers and of filters are characterized by absorption or transmission *curves*, with reference to radiant energy.

The *human eye* is a selective receiver of radiant energy. It responds to light. Light is defined by the I.E.S. as "radiant energy evaluated according to its capacity to produce visual sensation." Exact quantitative terms can only be given for what is known as the Normal Observer—an international standard based on thousands of experiments—because

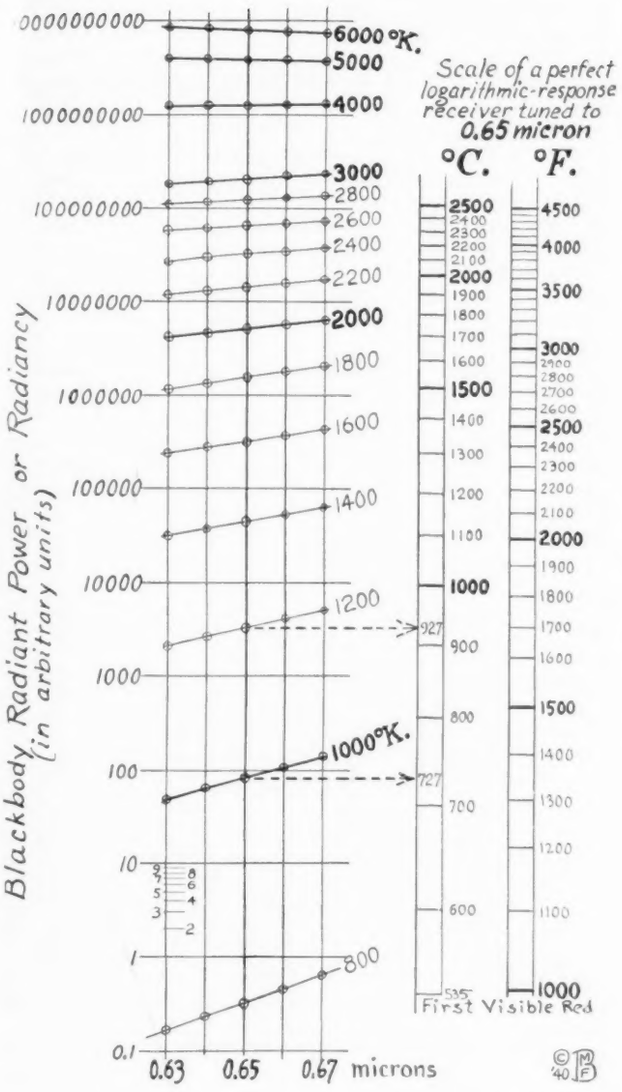


Fig. 6. The foundation of monochromatic optical pyrometry.

individuals differ widely, even without considering color-blindness and other abnormalities, and because the eye is not an ordinary physical receiver but a psycho-physical receiver whose constants are affected by subjective variations —fatigue, experience, attention, etc.—and by organic disturbances in remote parts of the body.

The eye responds, roughly speaking, to one octave of radiation: 0.4μ to 0.8μ. These are the easily-remembered round numbers. Many individual eyes respond to 0.3μ (which is "ultra-violet" for others). Many individual eyes respond to 1μ (which is "infra-red" for others). In such cases the visual sensation is obtained by using an extremely powerful light source in the apparatus: only a small part of the radiant energy is seen as light; the other 99+ percent produces discomfort or injury if the experiment is unduly prolonged. Between 0.5 and 0.6μ lies the region of maximum sensitivity for all eyes; most persons have no difficulty in seeing the 0.33μ violet and the 0.77μ red at comfortable intensities. The wave-lengths which produce the various colors most unmistakably are as follows:

Violet	0.41	Yellow	0.58
Blue	0.47	Orange	0.60
Green	0.52	Red	0.65

The visibility curve at daylight intensities bears a striking—and natural!—resemblance to the sun's energy distribution at the surface of the earth, as filtered by the atmosphere. This Normal Observer curve is shown in Fig. 7. It is known also as the visibility function, the luminosity curve, etc.

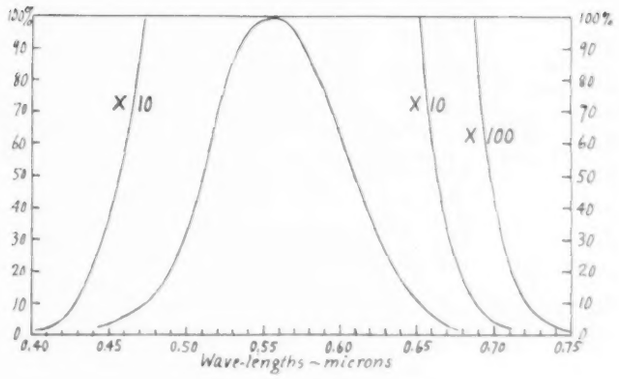


Fig. 7. The visibility curve.

At high intensities the maximum of the curve lies more in the yellow; at low intensities it lies in the green, between 0.50 and 0.52μ. Therefore, the idea of using 0.70 or even 0.72μ glasses for pyrometry, while attractive from the standpoint of extending ranges and obtaining faster response at low temperatures, would result in eye-strain and poor matching. Besides, the usual 0.65μ glasses are so designated because of their center of gravity with reference to *light:* most of them transmit twice as much *energy* at 0.75μ than they do at 0.65μ.

This brings us to the relations between radiant energy curves and light curves. The visibility curve is the starting point of calculations, definitions and values. Thus, by mul-

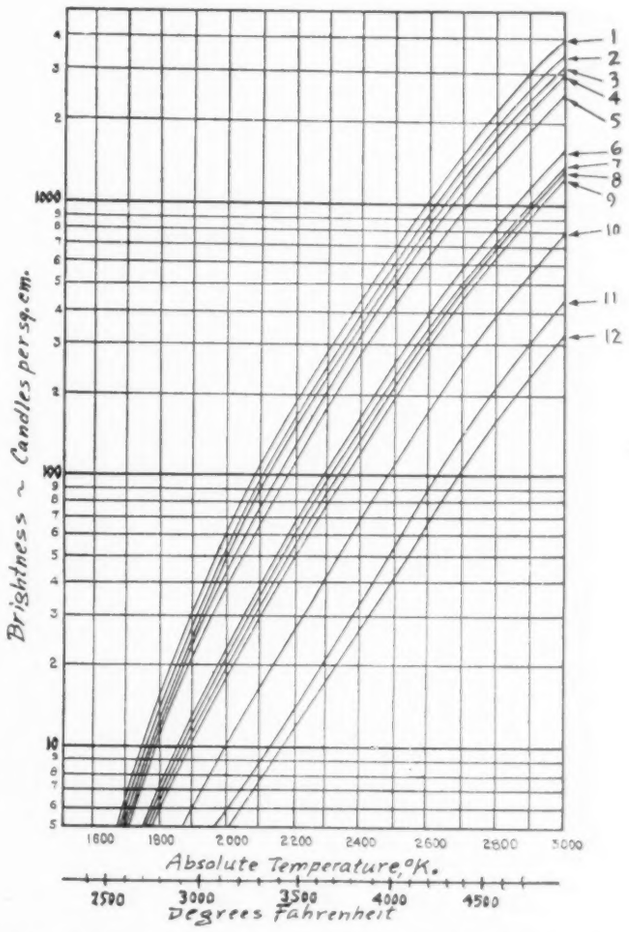


Fig. 8. Relation of brightness to temperature for the blackbody and various materials. Values are accurate for the blackbody; they are increasingly rough as the "emissivities" decrease, beside having been extrapolated beyond some melting-points. 1. Blackbody. 2. Lampblack or carbonized nickel. 3. Iron oxide (Fe_2O_3). 4. Carbon. 5. Carbon filament. 6. Tantalum. 7. Tungsten. 8. Molybdenum. 9. Platinum. 10. Copper. 11. Aluminum oxide (Al_2O_3). 12. Magnesium oxide (MgO).

tiplying the ordinates of any blackbody curve of spectral *radiant* intensities by the corresponding visibilities, there is obtained the blackbody curve of spectral *luminous* intensities for the temperature of the blackbody. Obviously, the curve of a blackbody at room temperature, or at any temperature below the first visible red, cannot be translated into a luminous intensity curve. Obviously, too, the *brightness* (area under the luminous curve, corresponding to the

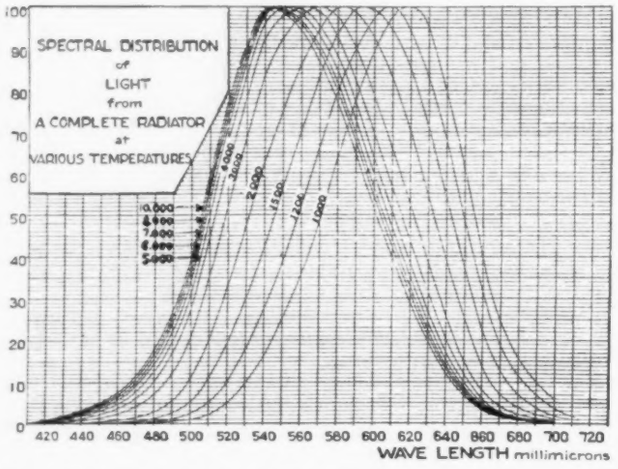


Fig. 9. These are luminosity, not radiant energy, distribution curves. *(Priest)*

radiancy of total radiation) increases as a higher power of the temperature than does the radiancy. See Fig. 8 (and compare it with Fig. 8 of the preceding chapter on Radiation Pyrometry.)

Another effect is that the luminosity curve shifts toward the shorter wave-lengths as does the energy curve, but always stays within the spectral limits of visibility. Fig. 9 is

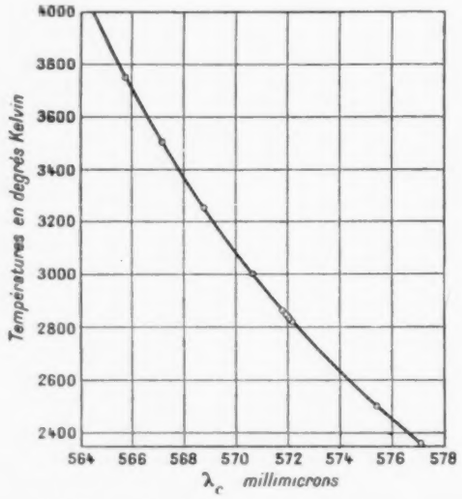


Fig. 10. Unlike that of the energy curve, the center of gravity of the luminosity curve does not pass into the ultraviolet, however high the source temperature. *(Ribaud)*

from the famous *Bu. of Stds. Sci. Paper 417* (1921) by Priest: it shows a series of the luminous curves for eleven temperatures, all plotted on different scales so that the peak luminosity is always "100."

The centers of gravity of blackbody luminosity curves shift toward the violet as shown in Fig. 10 (from Ribaud who plotted values computed by Priest).

Figs. 9 and 10 bring out the basis of *"color temperature."* The color temperature of a body is simply the temperature of a blackbody having the same color. In Forsythe's more precise terms, the color temperature of any non-blackbody is "the temperature at which it is necessary to operate a blackbody so that its radiation will match in integral color the source studied."

The *brightness temperature* of a non-blackbody, similarly, is the temperature of a blackbody having the same brightness *at some specified wave-length.*

Another interesting approach to the subject of the color of blackbody radiation began as far back as 1881 when Crova first pointed out that there exists a wave-length in the spectral energy curves of two sources, at which wave-length (known as the Crova wave-length) the ratio of the two radiant intensities equals the ratio of the two total luminosities. For many years this wave-length was believed to be a constant of the human eye, and by the beginning of this century the value of this supposed constant was given as 0.58μ.

Not until after 1910 did Ives, Nutting, Foote, and other workers demonstrate that there is no such constant. However, the experiments led to the publication of various types of families of curves which in turn, when studied by numerous pyrometrists throughout the world, aided in fixing the concepts involved. In the report of one famous series of experiments, Priest included a figure showing a family of curves of blackbody radiation pertaining to what was then

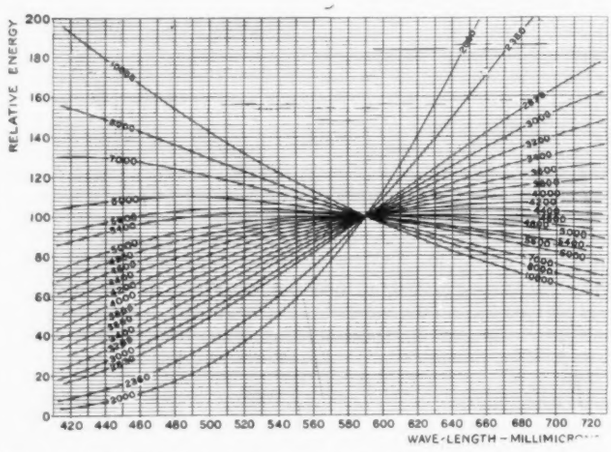


Fig. 11. Here again, energy curves—or portions thereof in the visible—all drawn to make the energy at 0.59 micron equal "100." *(Priest)*

known as the "yellow-blue transition temperature." In that diagram he had all spectral energy distribution curves plotted with the 0.59μ ordinate arbitrarily fixed at 100. In his later paper* he published the diagram here reproduced as Fig. 11. Note that the abcissa extend over the visible spectrum only: in visual pyrometry the entire portrait of radiation does not have to be depicted.

This type of diagram is frequently used for specifying the colors of illuminants. As a matter of interest, it may be mentioned that average noon sunlight at the latitude of Washington, which actually has an irregular distribution when narrow wave-length intervals are carefully measured, is closely approximated by the 5000°K. curve of Fig. 11; the average daylight at Washington (also an irregular curve actually) by the 6500°K. curve of Fig. 11; and the blue sky by the 10000°K. curve. We repeat, these are blackbody spectral *energy* distribution curves.

The chief value of Fig. 11, however, is that it brings out the scientific basis for bichromatic pyrometry. It is evident that for every blackbody temperature, there is a ratio of spectral radiant intensities in the red and in the blue, which ratio varies rapidly enough to make possible accurate temperature measurements without need of close measurements of the two radiant intensities—translated as the two *brightnesses.*

Now, when we examine the luminosity curve, Fig. 7, we note that the sensitivity of the human eye at 0.47μ is 10% of its maximum and also 10% at 0.65μ. Therefore, a pair of photometric devices, one with a 0.47μ blue glass and one

*J.O.S.A.&R.S.I., Vol. 7, 1923, page 1175.

with a 0.65μ red glass, will constitute a pyrometer which does not require measuring the two spectral brightnesses but only their ratio. Ribaud, Forsythe and other workers have worked out the mathematics of this bichromatic pyrometry when applied to non-blackbodies. Ribaud has shown that there are certain relations which can be plotted as straight lines. This branch of visual pyrometry has a promising future. Of the pyrometers now being manufactured, however, it may be said that they only represent a beginning. Another beginning may be chronicled in a related field, namely the measurement of color temperatures of illuminants in amateur photography by means of "color temperature meters" which utilize the bichromatic ratio principle. The first of these to appear on the market is that made by the Eastman Kodak Co. It is described at the end of this chapter but we may quote here two paragraphs from the instruction book, applicable with even greater strength to the *pyrometers* belonging to this class of temperature-measuring instruments:

> In reading the instrument, it is always good practice to make a number of determinations, say, at least five, and take the average. With experience, it is possible to read the color temperature of studio lamps to an accuracy of less than fifty degrees.
>
> The use of the instrument presupposes normal color vision. *Color blind people will not be able to use the meter, and neither will those who have certain abnormalities in their color vision.* There is much difference in the color accommodation between different people and sometimes between the two eyes of the same person. [The makers of candid cameras are candid about the limitations of this *class* of temperature-measuring instruments!—MFB]

Visual Pyrometry of Non-blackbodies. — Graybodies. A graybody material is one whose emissivities are all less than unity but are all equal. There is no such material from the standpoint of total-radiation pyrometry. In monochromatic visual pyrometry, only one set of the spectral emissivities is of interest. When these vary but little with temperature they can be compiled in usable tables—and have been for some materials. In short, the "double infinity of factors" (Forsythe's apt phrase) which makes accurate radiation pyrometry so difficult in so many cases, though not theoretically reduced to a workable minimum, is practically reduced to perhaps three listings.

So much for any graybody material. An actual body made of that same material will not have the tabulated graybody properties unless its surface is clean and polished. Even so, it must not be inferred by the reader that all the emittance values at any wave-length will be uniform. Differences are frequently found. For example, the incandescent surface of the helical filament of an ordinary lamp, when viewed under a microscope through two or three colored filters (to obtain an extremely narrow wave-length interval: spectral purity) shows graduations from bright to dull, depending on the angles of emission—the azimuth angles and the altitude angles. Such a surface has passed through diamond dies, has been untouched by hand, and when fresh from the factory has not been oxidized or otherwise affected: it is mechanically uniform but nevertheless displays a variable relation of temperature to spectral luminous intensity. Therefore the published value of the "emissivity" (even the normal spectral emissivity) of any important material should not be assumed to hold true for all the emittance properties of an actual body made of that material.

Actual non-blackbodies. Since the great influence of the character of actual surfaces is *visible*, the pyrometrist quickly acquires the habit of sighting certain kinds of spots or regions, and avoiding others, when taking reading on slabs, etc., whose surfaces are non-uniform. Experience thus gained then proves valuable when measuring temperatures of different materials having different non-uniform surfaces and consulting tables of "emissivities." It always is extremely important to make sure that the data apply to the particular kind of surface whose temperature is to be measured. At this writing (1940) correction charts subdivided into tables referring to specified surfaces have been published for only a few important materials; and they are far from complete. There are some useful bits of data, however, such as on molten-metal streams and other widespread in-

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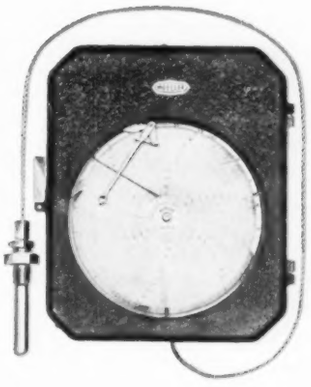

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dustrial applications. At present the accuracy of visual pyrometry is spotty: extremely high where emittance corrections are known and correctly applied, unsatisfactory where guesswork is compelled for want of applicable specific data. What is needed is the compilation, for every important material, of a complete series of emittance *curves*—complete

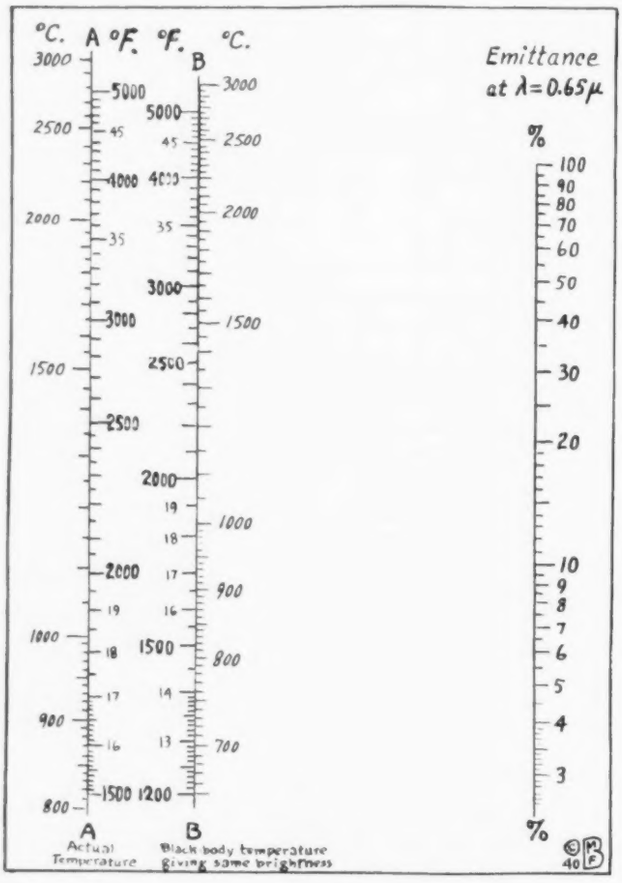


Fig. 12. Do not use this alignment chart unless you know your emittances.

except for unusual surfaces. Meanwhile, the serious pyrometrist should familiarize himself first of all with the terminology (Sec. 3 of Ch. X) as a first step in cultivating a critical attitude toward many *general* emissivity correction tables and charts . . . including for example Fig. 12 which was drawn by the writer of this negative advice!

Effects of Intervening Media. Visual pyrometry has a great advantage over total-radiation pyrometry in that the presence of intervening media between source and pyrometer is seen (an invisible medium cannot cut down the measured spectral brightness) and the seriousness of their effects readily estimated. Thus CO_2 and water vapor do not cause errors.

Transparent materials are gray media by reason of surface reflection. Thus a soap-bubble-thin sheet of glass or quartz has no color whatever, but it only transmits 92% of any wave-length in the visible; 8% is lost at the two surfaces. A visual pyrometer has a number of glass surfaces and therefore its initial factory calibration will remain constant so long as these surfaces are kept in their original condition. This seldom causes errors. Sighting a source through any solid medium, however, does make a difference, however clear the material and however small the thickness. An extremely useful correction chart has recently been constructed by Benford and is reproduced here (Fig. 13). The temperature scale across the bottom of the chart is, of course, the absolute scale, in degrees Kelvin, and the markings are the uncorrected degrees as indicated by the pyrometer. The curved lines may represent several factors such as (a) transmission factor of glass, (b) emittance of radiating surface, (c) combined effects of factors (a) and (b). Several examples were worked out by Benford to illustrate the various way in which his chart may be used:

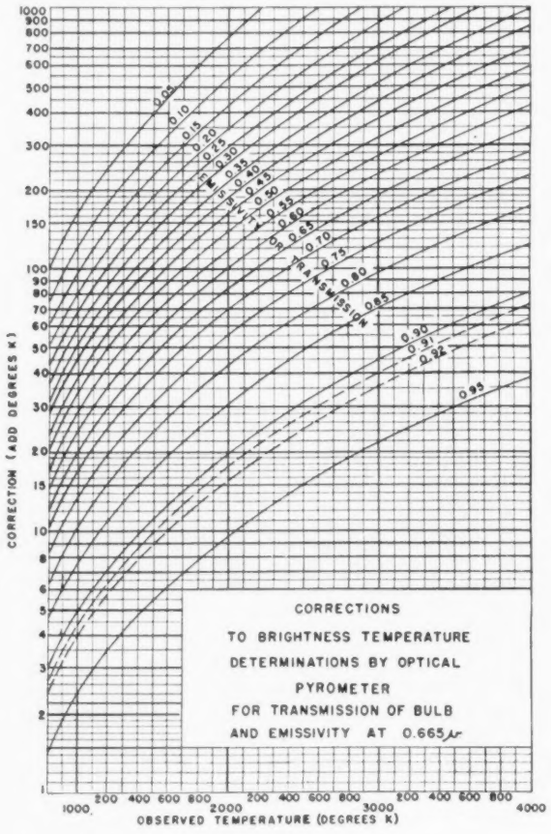


Fig. 13

Example 1. Bulb corrections are made as follows:

Observed brightness temperature	2800°K.
Bulb transmission (known)	0.91
Bulb correction (from chart)	35°
Corrected brightness temperature	2835°K.

Example 2. If the emissivity (at 0.665μ and at the test temperature) is known, the true temperature of the above radiator can be found as follows:

Brightness temperature (using observed temperature scale of chart)	2835°K.
Emissivity (known at 0.665μ)	0.60
Emissivity correction (from chart)	204°
True temperature	3039°K.

Example 3. From pyrometer readings on the surface of a radiator, and from readings on a cavity in the same radiator the emissivity is determined as follows:

Surface reading	2200°K.
Bulb transmission (known)	0.91
Bulb correction	22°
True brightness temperature	2222°K.
Cavity brightness (observed)	2550°K.
Bulb correction	29°
True cavity brightness temperature	2579°K.
Difference, cavity minus surface	357°K.
Ordinate at 2222° on temperature scale and abscissae at 357° on correction scale cross near curve marked 0.25 gives emissivity	0.26

Example 4. A filament observed through a clean section of bulb has an observed brightness temperature 45° higher than when observed through a section having a thin metallic coating. The transmission of the coated section can be found with the aid of the chart.

Reading through clear surface	1500°K.
Bulb transmission (known)	0.92
Bulb correction	9°
True brightness temperature	1509°K.
Reading through coated surface	1360°K.
Loss in coated section (1509–1360)	149°K.
Curve at 1360° ordinate, 149° abscissae	0.22
Bulb transmission	0.92
Deposit transmission (0.22/0.92)	0.24

*Frank Benford, Temperature Corrections in Optical Pyrometry. *Journal Optical Soc. of Am.*, Vol. 29, April 1939, pages 162-163.

4. Industrial Forms

Complete coverage of the makes is not intended in this section. Only a few examples are selected. The descriptions being designed to bring out technical features one by one when read consecutively, only the first in each type is adequate, the others purposely brief.

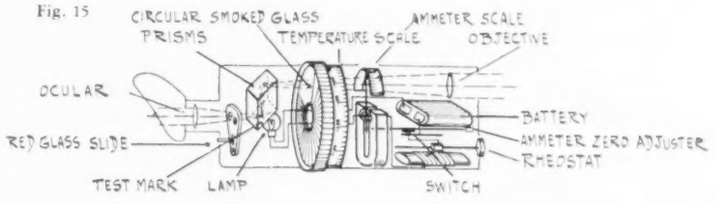
(a) Brightness-matching

CLASS I—PHOTOMETRIC

Combridge Instrument Co.'s Nicol Prism Type. This is a photometer in which monochromatic light from the object sighted is adjusted to equal intensity with a beam of similar light from an incandescent lamp: Light from the source enters the instrument through one aperture while through another enters light from the lamp. The two beams pass through an optical system whereby they are polarized in different planes, and rendered monochromatic; they then pass through a Nicol prism into the eyepiece. The field seen by the observer is divided into two semi-circles, illuminated by the source and the electric lamp respectively. The eyepiece, to which is attached the scale pointer, is rotated until the two semi-circles are equally illuminated, and the temperature is then read directly on the scale engraved on the large circular plate (which forms a convenient shield). The electric lamp is checked against standard amyl-acetate lamp supplied with each outfit, and its current standardized by altering the resistance accordingly. Double-scale instruments are provided with an absorbing screen, which is moved in front of the objective when using the higher range. Standard ranges for single-scale instruments are 700 to 1400°F. and 900 to 2000°C. For double-scale instruments, the same two and others up to 4000°C.

Fig. 14

Fig. 15



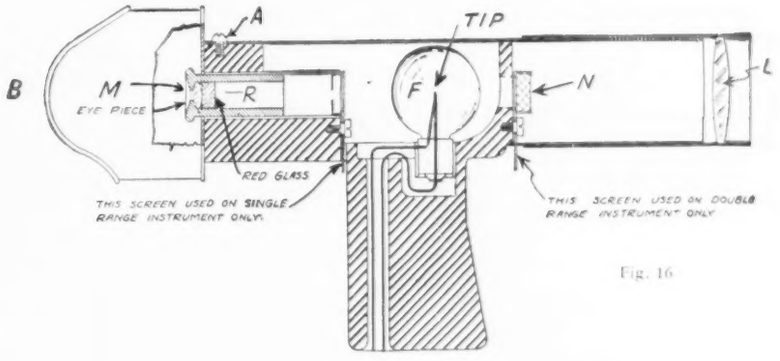


Fig. 16

"Pyro." (Pyrometer Instrument Co.). This is a German-made self-contained instrument (weight 3 lbs.) employing a photometric cube device whereby the *central* part of the field of view is illuminated by the lamp, and a circular wedge for attenuating the brightness of the source until the small inner circular part of the field and the large annular part of the field are brought to a match. The wedge is a circular one, made of clear glass with an emulsion of varying density on it. Lamp current is standardized by the rheostat and ammeter, used in conjunction with a "master lamp" inserted periodically in place of the working lamp, at which time the temperature scale is adjusted. Between standardizations, lamp current is then checked by pressing the ammeter contact button and adjusting the rheostat only. Other construction details are brought out in Fig. 15.

CLASS II—DISAPPEARING-FILAMENT

Leeds & Northrup Co. (1) Morse Type. This model was superseded in 1939 but many are in use and on the market. It is of the variable filament temperature type developed under the Morse patents. Construction of a late model is shown in Fig. 16 which brings out the telescope features of most portable disappearing-filament pyrometers. The image of the source is brought to a focus at *F* by the object lens *L*. The tungsten filament is placed in the plane of the image produced by the lens. The lamp current (from a battery in a portable case which contains the rheostat and the milliammeter) is adjusted until the brightness of the filament is equal to that of the object (see Fig. 3). Screen *N*, made of a suitable dark glass, is used for the measurement of temperatures above 2500°F. A different calibration is used with the absorbing screen (because the effective wave-length is altered) but the range without the screen and that with the screen overlap by several hundred degrees. This makes it possible to check the correspondence of the two scales within the overlapping portion.

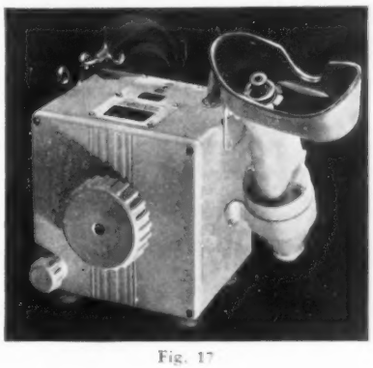


Fig. 17

Leeds & Northrup Co. (2) Potentiometer-circuit Type (Fig. 17). Brought out in 1939, this is not a new model of the L&N Morse type but a different instrument employing a potentiometer circuit (as do laboratory pyrometers such as that shown in Fig. 5). Its comparison lamp is of the new form described in Section 3: inclined flat sides, etc.; and the telescope as an optical instrument has been designed for industrial pyrometry and for use with the new form of lamps. Total weight of outfit is one-third that of the previous L&N model described above. The potentiometer circuit

itself (Fig. 18) is radically new and will no doubt find other applications where small currents must be measured rapidly and accurately. The lamp current can be adjusted by means of slidewire rheostat A when switch G is closed. The curometer slidewire B and its end-coil C. The potentiometer slidewire can be considered as being a variable shunt whose resistance is adjusted so that the product of the lamp current and the shunt resistance is equal to the emf. of the standard cell. It has been shown† that C and the shunted value of B can be determined for a lamp requiring known maximum and minimum currents to cover the temperature range. The scale associated with contact P can be calibrated in milliamperes or temperature. In optical pyrometers with direct-reading temperature scales the lamps must have uniform calibrations and some provision must be made whereby the same scale can be used with replacement lamps. In the new L&N instrument the adjustment of the temperature scale relative to contact P (which in effect changes C), and the replacement of shunt coil B', are all that is necessary when making a lamp replacement. The lamp is operated (by

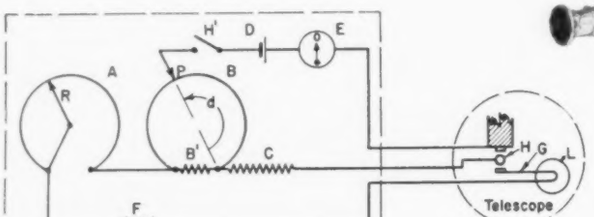


Fig. 18

four flashlight cells) at 20 to 60 milliamperes and over this range a change of 0.1% in current changes the filament temperature approximately 1°C. Galvanometer E has sufficient sensitivity to detect a 0.1% unbalance of the potentiometer. It is doubly protected against dust but even if magnetic dust should reach the movement it could only affect the sensitivity of setting, not the calibration of the pyrometer. It has been shown that a further increase in accuracy of temperature readings cannot be expected by making the current measurement more accurately.

As a result of the equal frequency of "charging" and "discharging" currents, a much larger current drain on the standard cell could be permitted than that of normal use. However, to minimize this source of error and to secure easy and rapid manipulation of the instrument, a mechanical device is used which keeps the potentiometer roughly adjusted for all lamp currents. This device consists of means for mechanically coupling the rheostat and potentiometer slidewire contacts in such a way that when the rheostat is moved (by means of the large knob, Fig. 17) to adjust the current, the potentiometer contact is carried with it in the direction required to maintain potentiometer balance, but when the potentiometer contact is operated (by the small knob) the rheostat contact remains at rest. Thus, it is possible to maintain a rough adjustment of the potentiometer while the lamp current is altered and, further, to balance the potentiometer without changing the current through the lamp. It can be seen from Fig. 18 that both contacts R and P must be near their right-hand limits for the maximum lamp current and corresponding potentiometer balance. If now the resistance of the rheostat A is no greater than is necessary under the condition that new cells are used at F, it is evident that if the potentiometer has been balanced for one position of R it will be automatically kept in approximate balance for all positions of R. Without the differentrial-clutch coupling, currents as large as 3000 microamperes could occasionally flow through the standard cell. In practice the mechanism is said to be so effective that when a series

†*Review of Scientific Instruments*, Dec. 1939, pages 386-388. (Article by R. C. Machler of L&N giving detailed description of new circuit.)

of readings of temperatures within a narrow range is being made it is unnecessary to rebalance the potentiometer after each reading. This new model is of course available with various styles of telescopes, with or without pistol grip, in Fahrenheit or Centigrade ranges, etc. No need to detail the numerous "features."

"F & F" (Fisher Scientific Co.). In this instrument, a "geometric wedge" is interposed between the source and the filament. Fig. 20 is a diagram of the optical system: a telescope with objective lens A and ocular lens D, lamp C with a hairpin filament mounted in the focal plane of the objective, the tip of the filament being viewed through the ocular. The filament operates at constant brightness. B is an adjustable wedge of absorbing glass, whereby the

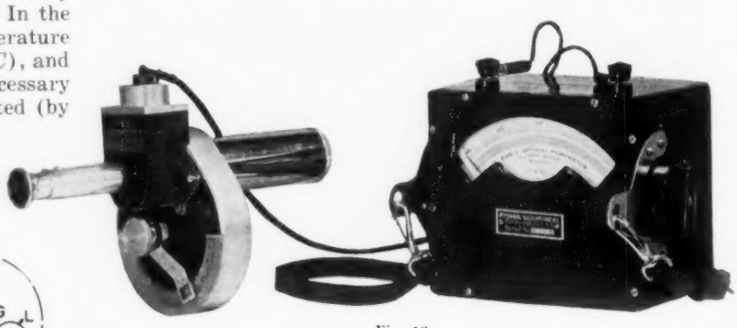


Fig. 19

Fig. 20

brightness of the image of the source may bet set to a photometric match with the filament. In the actual instrument the wedge is not linear but semi-circular as in the "Pyro" instrument. The F & F wedge, however, is solid or geometric, the graduated density being produced by a variable thickness of dark glass. The absorbing glass is cemented to a similar semi-circular wedge of clear optical glass of the same refractive index. The combination is accordingly a disk of a uniform thickness. The pointer which indicates the temperature is directly connected to the wedge mounting. The standard range is from 1600 to 4000°F. This instrument was developed in America by the makers.

Foster Instrument Co. A portable telescope combined with ammeter but separate from the battery. Adjustment by controlling current through filament. A feature is the "lamp bridge unit" by means of which the whole scale is used. The lamp filament is made one of the arms of a Wheatstone bridge and the milliammeter is used as the bridge galvanometer. The method is that of the *semi-potentiometer* (see Sec. 9, Chapt. IX) and possesses the advantages of that circuit. At the same time, the units of bridge and lamp combined are made interchangeable. Another model is made without a lamp bridge unit system. Still another model is made with a separate indicator instead of the small one mounted on the telescope, and two rheostats: one for coarse adjustment and one for close matching.

"Pyro Micro-Optical" (Pyrometer Instrument Co.). This instrument's purpose is described by its name. Magnification being 20×, the outfit includes a rigid support and tripod, with worm-gear directional adjustments. One obvious use is the accurate measurement of temperatures of bodies of unknown or low emittance properties (for example, specimens of new materials on which research is being conducted) by placing such bodies in a blackbody furnace or by sighting into narrow cavities in such bodies. Another use is the pyrometry of molten metals by sighting the bottom of a closed-end refractory tube (of known emittance) immersed in the bath. A "precision ammeter" with built-in battery is in-

cluded. The instrument is furnished with the following scale ranges: 600-1600°C., 1600-3000°C., 3000-4000°C., or F. equivalent. An objective of 37-mm. aperture produces a reversed image of the object to be measured at about 6" (15 cm.) distance; it is viewed through the ocular which acts as a microscope. The ammeter is intentionally not calibrated in temperatures as the scale would change every time a

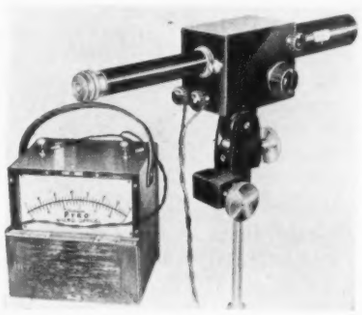


Fig. 22

lamp is replaced by a new one. The instruments are supplied with calibration curves from which the temperature corresponding to the galvanometer readings are taken. On special request, the ammeter can be furnished with a direct-reading temperature scale. The ammeter is compensated for variations in room temperature, and is of the suppressed-zero type in order to make better use of the scale. The zero adjuster is sealed and must be used only if the current is checked, in a suitably equipped laboratory, with a potentiometer.

The "*Pyro Remote Optical*" differs from the above in its lens system. It is used on sources which appear small at a distance and require a 15× telescope for proper viewing.

Siemens & Halske Cross-filament Type. In this instrument the lamp contains two crossed filaments of materials of different current-brightness characteristics intersecting (Fig. 21) at a temperature which serves as a comparison temperature, the two filaments then appearing equally bright. By

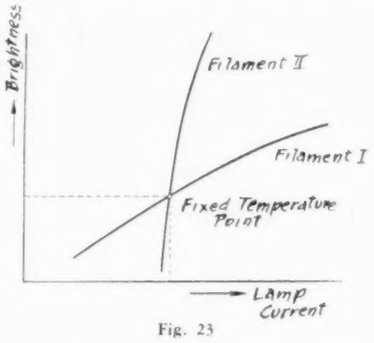


Fig. 23

means of an absorbing wedge between objective lens and lamp, the luminous radiation of the source is attenuated until the source and the cross-filament appear equally bright. This measuring method makes possible measurement without an electrical indicating instrument. In order to facilitate the adjustment of the two filaments to equal brightness, one is shaped as a broad ribbon so that it acts as background for the (other) round-wire filament. This adjustment is said to be made without difficulty to an accuracy of about 3°C.

Chauvin & Arnoux (France). A semi-self-contained instrument weighing a little over two pounds. Current supplied by either dry battery or lightweight storage battery slung from the shoulder. Distinctive features: (1) No dead space on scale, the zero at 600°C. coinciding with beginning of perception of light from source through the monochromatic filter. (2) Scale evenly graduated for 9/10 of its length. (3) Rheostat worked by one finger.

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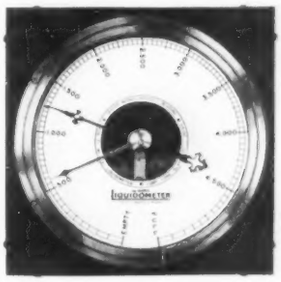

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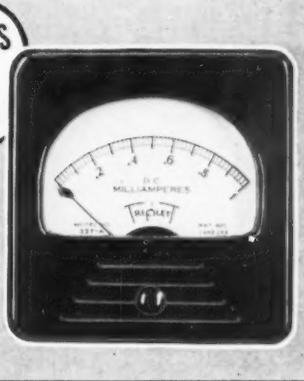

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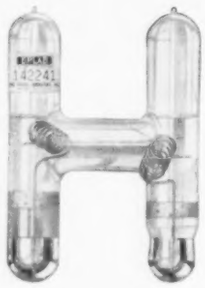

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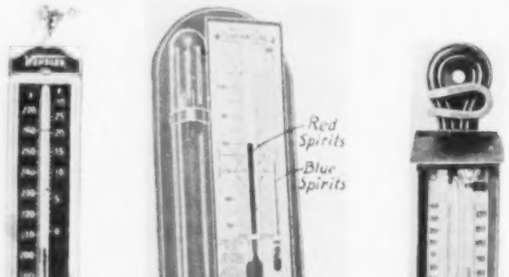

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(b) Wedge or Extinction

EXTINCTION OF TOTAL LUMINOUS FLUX

"Wedge" (The Optical Pyrometer Syndicate). This English instrument is self-contained and shaped like a plus mark, consisting as it does of a telescope and a long housing in which the straight wedge is moved up or down. The makers state that the prism is made of specially prepared dark glass, so arranged that it cuts off the light emitted by a heated body at various temperatures. For example—in looking at a heated bar iron, supposing the temperature to be 1000°C., then on turning the screw the thicker part of the prism comes gradually into the field of vision, the bar appears gradually darker till at a given point the object entirely disappears; then, "on looking at the scale, the pointer will be seen at 1000°C." A little practice is required to decide the exact point at which the object disappears.

"Pyroversum" (Ströhlein & Co., Germany). Same principle as the English "Wedge" but simpler construction. It resembles a slide rule: A frame about 7" long encloses a shaded glass ranging from clear at one end to opaque at the other. One looks through a hole in the sliding eye-piece, which one pushes along the frame until the glow becomes invisible. One then reads the temperature by the position of the slide on the scale along one edge of the frame.

EXTINCTION OF MOST-VISIBLE WAVE-LENGTH

"P2" (Same make). Same idea as the "Pyroversum" but minus the sliding eye-piece. The framed glass is held between the eye and the glowing object; it is moved until the glow vanishes, and one marks the place on the graduated edge with one's finger. The glass is green in its "effective wave length" so that extremely high temperatures can be measured fairly closely by an experienced observer—if the source is nearly a blackbody, because standard emissivity corrections (for $\lambda = 65\mu$) are inapplicable.

(c) Color

"Pyrovisor-H." This German instrument (American Demag Corp., agents) closely resembles the "Pyroversum" in construction, but it is used to measure the temperature of the source by determining the ratio of the intensity of an almost monochromatic band in the red end of the visible spectrum to that of a similarly narrow band in the green portion. This ratio is ascertained by means of what may be described as a green-red double wedge, one end transmitting more green than red and the other end more red than green, so that there is a definite green-red ratio for every point along this strip of glass. We quote:

"The temperature of the body is therefore measured simply by finding that spot in the light filter where neither the green nor the red color is distinctly visible but where both colors fuse and become white in appearance . . . For very accurate readings, find first with one eye the approximate spot where both colors fuse together, then switch over to the other eye and determine the correct spot of the fused colors by moving the color glass slightly in both directions until the exact location is found where the color appears neither red nor green. It is important in order to avoid color fatigue of the eye, not to look at the glowing body for too long a time through a part of the glass which shows a distinctly green or red color. It will take a few days to become fully accustomed to the Pyrovisor and to obtain quick and accurate temperature readings."

"Bi-Optical" (Pyrometer Instrument Co.). Unlike the device just described, this instrument is designed for laboratory and research work and comes with the rigid support shown in Fig. 23. It has two purposes: (1) the measurement of color temperatures of illuminants; (2) the measurement of temperatures of bodies of unknown emittance properties, these bodies being assumed to be graybodies at high temperatures—an "if" which does not appear in the 2000-word description from which the following is abstracted:

The filter is composed of two filters placed one behind the other. The first filter is of plane form, and completely screens certain parts of the spectrum of the source. Behind this filter is placed a second filter not of plane form, which transmits part of the colors allowed to pass by the first filter but absorbs the remainder to an extent which increases gradually.

In consequence of the variations in the degree of absorption of different colors, there is produced a mixture of light rays which has at all points a different spectral distribution and therefore a different color. The colors which pass through the first filter thus merge at a particular point of the second filter

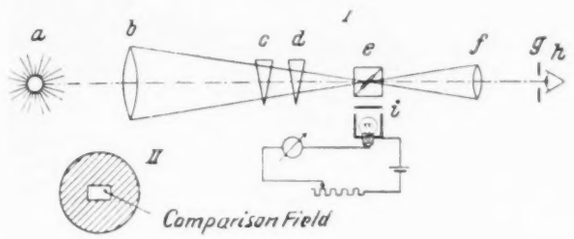

Fig. 24

to form a mixed or neutral color. The part of the filter at which this mixed or neutral color is formed is dependent, in a filter of given transparency, on the spectral distribution of the rays emitted by the source and therefore on the temperature thereof. The point at which the mixed color appears is employed as an index of the temperature of the source.

The employed colors, green and red, produce, mixed in a definite ratio, the impression "white" in the eye, the best suited mixed color as recollection color. Since the eye possesses the greatest sensitivity for green and orange, this mixture is the most suitable one for the purpose.

The comparison field of illumination—in the form of a "yellowish-white" luminous rectangle—possesses, after complete adjustment to color and brightness, the same spectral energy distribution as the field to be measured. The device for adjusting the brightness serves to determine the blackbody temperature.

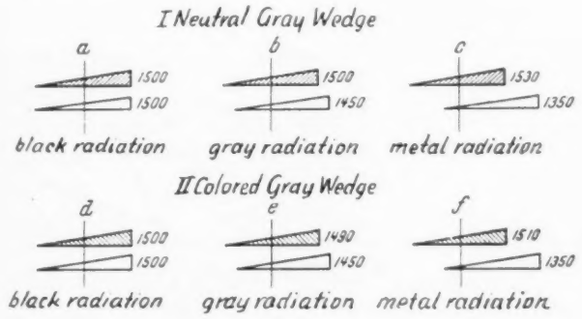

Fig. 25

The light of source *a*, Fig. 24, falls through telescope objective *b*, ocular *f* and diaphragm *g* into the eye of the observer *h*. Bichromatic color wedge *c* is inserted into the path of the ray which allows only the red and green light to pass and permits, furthermore, change by shifting the intensity ratio of these colors as it absorbs the two colors with increasing thickness to a different degree. Neutral wedge *d* allows a change in brightness. Photometric *e* permits matching illumination of comparison lamp *i* and principal beam. Parts *c* and *d* are inserted each by an adjusting scale ring so that both color and brightness of the field to be measured agree with the comparison field. The color temperature is established by means of the color wedge *c* and the temperature corresponding to the blackbody by means of the gray wedge. The difference between the two scale indications shows whether radiation of a blackbody or of a bright metal exists.

Fig. 25 shows the position of the two wedges with respect to each other for blackbody (*a*), graybody (*b*) and radiation of bright iron (*c*). For blackbody radiation the two instrument scales agree. For graybody radiation the color temperature coincides with the "true" temperature while "blackbody" temperature is considerably lower. In order to have agreement between color temperature and "true" temperature also for the radiation of bright metals, the color temperature read on the instrument is approximated so closely to the "true" temperature with a colored gray wedge that the color temperature can be considered in all technical cases—that is also for radiation of bright iron (*c*)—as the "true" temperature (*d*, *e*, *f* in Fig. 25).

Eastman Color Temperature Meter (*Eastman Kodak Co.*). Chief purpose of this instrument is to determine the color temperatures of illuminants in order to regulate lamp voltages or otherwise provide the correct quailty of light for indoor color photography, or select the correct filter for the camera lens. Therefore it *can* be used for measuring color

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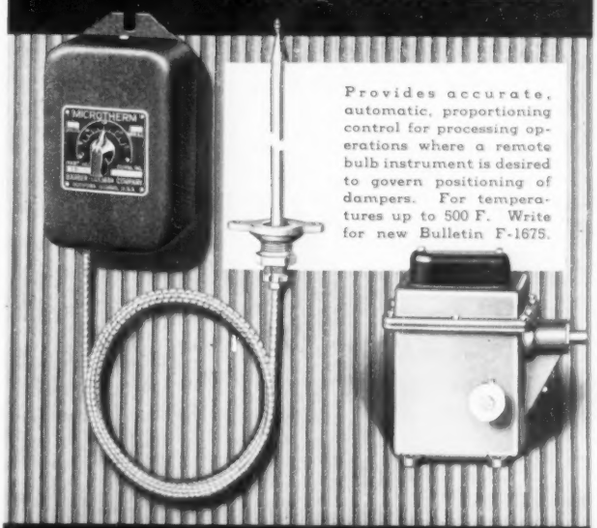

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temperatures of sources other than studio lights, etc. It employes a diametrically-divided circular field, half of it illuminated by the source through a filter of yellow effective wave-length, the other half through a green-to-red tapering filter as in some of the above-described instruments and devices. This second filter is rotated until both halves appear yellow and match in color and brightness; then the color-temperature scale attached thereto is read. The instrument comes with a special candle which burns with known spectral distribution and is used for setting the scale (to suit the eye of an individual observer) in conjunction with an accommodation adjustment filter. When viewed through this filter the candle flame has an effective color temperature equal to that marked on the filter mount. By means of the accommodation scale on the instrument a number of observers, each knowing his own accommodation factor, can then use the instrument without having to repeat this operation. Several brief passages from the instruction book are of such distinct interest to pyrometrists that they are quoted:

Values of color temperature can only be applied strictly to sources having an energy distribution resembling that of a perfect radiator. Tungsten filament lamps fall closely enough in this class. Some arc lamps, and other sources having discontinuous spectra should be said to have *equivalent* color temperatures, provided their color matches that of a perfect radiator. Discharge lamps, such as mercury, neon and sodium tubes, which have characteristic line spectra, cannot be said to have color temperatures.

Conditions of fatigue and eye strain make it important that the accommodation setting be redetermined occasionally. In measuring the color temperature of strong light sources such as studio lamps, the field may be too bright to permit an accurate reading. For this purpose the Eastman Color Temperature Test Paper is provided with the meter. Hold a sheet of this special paper in the full beam of the light and then direct the Color Temperature Meter toward it, and read the reflected light. The white paper supplied for this purpose is so chosen that the color quality of the light reflected from it differs only slightly from the color quality of the light falling upon it. *Ordinary white paper and other white objects will by no means be satisfactory for this purpose.* When the paper is used, 75° should be subtracted from the meter reading in order to obtain the color temperature of the source itself. The value 75° applies only to color temperatures about 3,000°K. The actual deduction to be made will depend on the color temperature indicated by the meter. At about 4,000°K. the deduction will be 130°, at about 5,000°K. the deduction will be 200°. Deductions for intermediate color temperatures should be roughly proportional.

Source	*Color Temperature, °K*
60-watt vacuum tungsten filament lamp	2,509
100-watt gas-filled tungsten filament lamp	2,865
500-watt gas-filled tungsten filament lamp	2,960
1,000-watt gas-filled tungsten filament lamp	2,990
500-watt projection lamp	3,190
G.E. Mazda Lamp 3200 °K	3,200
Mazda C.P. Lamps	3,280
1,000-watt Photoflood Lamp	3,415
250-watt Photoflood Lamp	3,444
Photoflash Lamp, No. 21	3,800
White flame carbon arc	5,000
Mean noon sunlight at Washington, D.C.	5,400
High intensity sun arc	5,500

The color temperature of a studio lamp varies with the voltage: about 10°K per volt.

WARNING. It must be emphasized that people who are color blind will not be able to use the meter, and that some others who have certain abnormalities in their color vision will not be able to use it.

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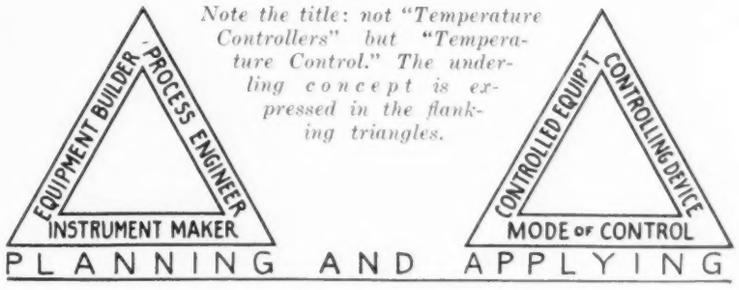
For further details, address L. O. Miller, Ass't Prof. Chem. Eng'g., Case School.

TENTATIVE PROGRAM
CASE LECTURE SERIES ON INDUSTRIAL INSTRUMENTATION

Lecture No.	*Evening*		*Speaker*
		A. General Introductory Lectures	
1	Tues., Feb. 4	Introduction. Classifications and Generic Properties of Measuring and Controlling Instruments.	M. F. Behar, Editor *Instruments.*
2	Thurs., Feb. 6	General Principles of Automatic Control.	J. J. Grebe, Dow Chemical Co.
3	Tues., Feb. 11	Functional Classification of Electrical Instruments.	P. L. Hoover, Dept. Elect. Eng'g, Case School.
4	Thurs., Feb. 13	Functional Classification of Electrical Instruments.	P. L. Hoover.
5	Tues., Feb. 18	Principles Involved in Air-operated Controllers. (Demonstration of instruments)	Brown Instrument Co. representative.
		B. Temperature Measurement and Control	
6	Thurs., Feb. 20	Fundamental Principles of Temperature Measurement.	Dept. Chem. Eng'g, Case School.
7	Tues., Feb. 25	High Temperature Measurement and Control Instruments. (Chiefly Optical and Radiation.)	Brown Instrument Co. representative.
8	Thurs., Feb. 27	Lower Temperature Measurement and Control Instruments. (Chiefly Thermocouple and Expansion Bulb.) (Demonstration of instruments)	Wheelco Instrument Co. representative.
		C. Pressure Measurement and Control	
9	Tues., Mar. 4	Principles of Pressure Measurement.	Dept. Chem. Eng'g, Case School.
10	Thurs., Mar. 6	Pressure Measuring Elements, Recorders and Controllers. (Demonstration of Instruments)	Taylor Instrument Co. representative.
		D. Fluid Flow Measurement and Control	
11	Tues., Mar. 11	Principles of Fuid Metering—Bernoulli's Principle (Calculations.)	Dept. Chem. Eng'g, Case School.
12	Thurs., Mar. 13	Principles of Fuid Metering—Meters, Calculations and Calibration.	Dept. Chem. Eng'g, Case School.
13	Tues., Mar. 18	Instruments for Measurement and Control of Fuid Flow. (Demonstrations including liquid level controls)	Foxboro Co. representative.
		E. Hydrogen Ion Measurement and Control	
14	Thurs.,Mar. 20	Fundamentals of pH Measurement.	Dept. Chem. Eng'g, Case School.
15	Tues., Mar. 25	Instruments for Measurement and Control of pH. (Demonstration of instruments)	Leeds & Northrup Co. representative.
		F. Other Fields	
16	Thurs., Mar. 27	Principles and Applications of Photoelectric Cell Equipment.	Wheelco Instrument Co. representative.
17	Tues., Apr. 1	Atmospheric Temperature and Humidity Control.	Minneapolis-Honeywell Co. representative.
18	Tues., Apr. 8	Automatic Gas Analyzers.	To be announced.
19	Thurs., Apr. 10	New and Specialized Instruments.	General Electric Co. representative.
		G. Plant Installations	
20	Tues., Apr. 15	Instrumentation in Petroleum Industry. (Where to Control.)	James Kearney, Austin Company.
21	Thurs., Apr. 17	Instrumentation in the Petroleum Industry. (How to Control.)	Foxboro Co. representative.
22	Tues., Apr. 22	Instruments for the Boiler Room.	Bailey Meter Co. representative.
23	Thurs., Apr. 24	Instrumentation in the Metallurgical Industry.	To be announced.
24	Tues., Apr. 29	Telemetering.	Bristol Co. representative.

Some ABC's of Automatic Temperature Control



Note the title: not "Temperature Controllers" but "Temperature Control." The underling concept is expressed in the flanking triangles.

Another fragmentary foretaste of the forthcoming revised edition of "T.M.&C." *This* part, however, stands largely as written eleven years ago.

By M. F. BEHAR

1. General Considerations.

A thermometer or pyrometer indicates what the temperature *is*. A recorder shows what the temperature *was*. An automatic temperature controller deals with the future: "Set it and forget it"—the old slogan of a pioneer controller maker—aptly sums up its liberation of man-power for more productive occupations.

Every temperature controller starts with a thermal system. Hence an acquaintance with the characteristics of the classes and types of temperature *measuring* instruments is required for an adequate understanding of automatic temperature control—controlling instruments, controlled devices and other elements of temperature control systems. Since thermometers and pyrometers have been dealt with in preceding chapters, their respective advantages, limitations and other characteristics need not be dwelt upon here, but these characteristics must be borne in mind. For example the differential-expansion thermometers (Chapter V), when considered as thermometers, are generally considered to consist of "not-so-accurate" rod types and "accurate" bimetal-coil types, but when we consider them as the thermal or primary systems we immediately revise our judgment: the rods are "powerful," the coils are "weak."

No controller can be better than its primary measuring element!

The thermal systems embodied in all temperature controllers obey the same physical laws as are obeyed by the corresponding indicating thermometers and pyrometers, but practical requirements have imposed far different forms in most cases. It is of interest that the *difference* between a temperature indicator and the corresponding thermal system of a temperature controller (for the same given range) is usually small for high-temperature applications, and becomes greater as the range lies lower. Thus in quickly glancing over the entire field of temperature control, one observes that pyrometric control systems start off with indicating and recording pyrometers to which a few extra parts have been added; whereas in the "hot-water" working ranges we meet a great variety of thermal systems which, while they have bulbs and connections identical with those of the indicators and recorders, differ widely inside the instrument case on the panel board (when there is anything at all resembling a case); and finally, in the field of refrigeration control, we come across specially designed thermal systems which, while employing one of the applicable principles of thermometry, resemble thermometers as little as a bell-ringing push-button resembles an automatic motor starter.

Since automatic temperature control won noticeable acceptance in industry with the turn of the century, the trend toward simplification—*where temperature indication was not required of the controller*—resulted in a variety of inexpensive thermostatic devices. These invaded the domestic field—whereupon competition arose and brought about even greater simplification. It was discovered long ago that whereas a temperature indicating instrument must be accurate over its entire range, the sensitive element of a thermostat need only be "accurate" over a narrow range. The on-and-off mode of control of the simpler devices further reduced the number of design factors. Quantity production led to standardization and an ever-increasing number of applications have been discovered, developed and exploited in the home, on the farm and in the office, as well as around the plant.

A parallel line of development combined the sensitive element with the actuating element: the same part which responded to the temperature turned the heat on and off as required. This simplification has reached what may be its triumphant climax in the Westinghouse "Klixon" for preventing over-heating of electrical appliances—a bimetallic disk which suddenly bulges at a certain temperature, and suddenly flattens back a few degrees lower, with sufficient strength to work the switch.

At the other extreme, we might mention certain systems of temperature control for blast furnaces and other large and important industrial applications—but we do not imply that these constitute the climax of complexity and cost.

At any rate such examples show the extent of the field of automatic temperature control. We can only deal with the *industrial* process temperature controllers—with the devices themselves without attempting to deal with their specific industrial applications—and sketchily at that . . . and *control* must be discussed before *controllers*.

Another thing which strikes one who travels his glance over the field of temperature control, starting with high temperatures and ending with refrigeration, is that the number of *specialized* and *standardized* thermal systems and relay systems is the greatest in the middle, tapering off at both ends. This is in exact accordance with the "penetration" of temperature control in winning the confidence of industry. As long ago as 1919, Fairchild and Foote of the Bureau of Standards, addressing the A.I.M.M.E. on "High Temperature Control," declared that "the greatest progress has been made in those industries in which the lower temperatures are used, particularly below 500°C. In this lower range automatic control has been highly developed."

2. Suitable Equipment Required.

This significant utterance, still applicable today, may be paraphrased; and it may be said that the development of automatic controllers is bound up with the development of automatic control. As in other fields of invention, the device which is ahead of its time can make little headway. Great as has been the extension of temperature control in industry, it is in its infancy, and its adolescence waits upon the growth and manifestation of a greater interest on the part of precisely that group of industrial engineers who would reap its greatest benefits. There is a limit, after all to the mind-reading ability of the instrument maker and to the power of advertising and salesmanship. The further development of automatic control and of controllers demands, first, a greater temperature consciousness on the part of prospective users of temperature controllers in industry;

second, the granting of a freer entrée to instrument men by the former and, third, a more receptive attitude on the part of the equipment mnaufacturer. It is high time for builders and manufacturers of furnaces, kilns, melting pots and tanks, lehrs, ovens, boilers, kettles, stills, towers, vats and of all other diversified industrial equipment, to realize that some among them are holding up the procession. It is high time for all to follow the example of a few who make "controllability" a part of design routine.

Every reader of this book probably knows of some temperature control installation which was turned off or disconnected "because it did not work." The chances are that the controller was not given the proper opportunity to fulfil its mission, the reason being possibly that it was abused and probably that the equipment on which it was installed was not suitable for its application. Articles on automatic temperature control frequently appear in industrial publications and their authors are prone to make the general statements (1) that any piece of equipment which cannot be controlled by hand cannot be controlled automatically —which is correct—and (2) that where temperature can be controlled manually it can be controlled automatically—which is wholly untrue with reference to the very applications which today still resist the conquest of automatic temperature control. It isa fact that in the case of several high-temperature processes *manual* control really means *visual* control, and that the furnace and kiln builders stick to their designs which were developed for the benefit of the old-time pre-pyrometry metallurgists and ceramists who worked by eye!

Such furnaces and kilns will have to be re-designed by or with the assistance of three groups of experts: (1) specialists in the proper application and location of thermocouples and radiation receivers which "feel" the temperature which is to be controlled; (2) specialists in the application of power-driven regulating devices; and (3) specialists in the combining of these two elements—engineers who might be called the liaison officers experienced in the performance characteristics of temperature control applications.

Finally, we must not forget the operating man's viewpoint. If the equipment is such that temperature control is not really automatic, he will be the first one to complain . . . or make trouble.*

2. Proper Installation Required.

Next to the application itself, which sometimes precludes automatic control and always limits the number of suitable temperature control hook-ups, the manner in which control is applied is a prime consideration. In many cases the man in charge of a process may cry in vain for close control, because even if he selects a type and make of automatic controller which, with its appurtenances, is likely to give him fairly good results, the proper installation of this temperature control system might require that the instrument company's engineer spend an entire week on that application . . . after spending months studying the process. That is one reason why automatic control has not yet been adopted for certain processes, especially for certain high-temperature processes. Not only have some furnaces not yet been sufficiently modified for the application of temperature control devices, as mentioned above, but the furnace builders, the instrument makers, and the metallurgists have not yet pooled their knowledge sufficiently to apply control in a scientific way to many furnaces which *could* be controlled. Instrument sales and service engineers cannot be expected to possess intimate knowledge of all temperature processes and of all types of temperature process equipment. Team work is required. Team work means "getting the signals," means understanding one another. It is too much to expect of processing equipment builders and users that they learn the language of the instrument fraternity. They need not even learn much about controllers. But they must understand *control.* Especially the industrial process man: his job —let it be repeated—is the conquest of variables, which is another name for control of all conditions. Temperature being an important condition he cannot afford to "leave it to the instrument salesman."

4. The "Four Requirements."

A thermometer or pyrometer merely reports—as would a subordinate sent by a manager to look over a situation; an automatic controller takes action—as would an alert executive to whom reports are submitted. All controllers are active, operating, "live" devices, to be judged by active performance, not by passive qualities.

The proper performance of a controller depends, as does that of a manager, on the correctness and timeliness of the infomation it receives, and on the limits within which its power may be exercised. Summarizing, we lay down the basic requirements for automatic control of process temperatures in industry:

(1) The temperature to be controlled, or its variation, must be measurable.

(2) The primary element of the automatic controller must be suitable for the measurement involve dand must be properly installed.

(3) The power device commanded by the control instrument must adequately control an adequate source of heat supply.

(4) The measuring means must command the corrective means effortlessly, i.e., without having its own measuring properties impaired.

Obvious and simple as are these four basic requirements, they are sometimes lost sight of in the maze of engineering details that have to be taken into account when working out elaborate installations.

5. Possible Classifications of Industrial Automatic Temperature Control Devices and Systems.

The above heading suggests one classification—the word "Industrial" excluding domestic devices.* Eve nrestricting our scope to the industrial temperature controllers, space limitations prevent their being treated exhaustively as mechanisms; there is a better use for this space than encyclopædic cataloguing.

Another possible classification is by the usual designations and what they stand for, but the nomenclature has not been standardized and as a matter of fact it would be hard to draw lines separating thermostats, heat regulators, temperature regulators, automatic temperature controllers and automatic temperature control systems—not to mention devices called by other names.

Another classification is into non-indicating, indicating, and recording automatic temperature controllers, these designations being self-explanatory. Usages vary somewhat in the application of modifications of these names. In the thermometric range we find such terms as "indicating controller" and "recorder-controller," both of which are self-explanatory. In the pyrometric range, "controlling pyrometer" is generally understood to mean an instrument which also indicates, while "recording controller" and "controlling recorder" are both used—seldom "recorder-controller." "Controlling potentiometer" is the usual designation when the system is based on that calss of instrument, the reason being that self-balancing potentiometers with control features are applicable without modification for the regulation of other conditions beside temperature: humidity, flow, level, pressure, gas analysis, pH, speed, light, etc. Moreover, self-balancing *bridges* with control features are commonly called "control potentiometers"—no doubt because they present the same outward appearance and are less numerous.

"Self-contained" and "distance" or other such terms suggest a simple and practical distinction between instruments

*Excellent discussions of design factors with regard to high temperature distribution and control are found in numerous papers presented at meetings of the A.S.M., A.S.M.E., A.I.M.E., A.I.Ch.E. and other societies in recent years; and printed in their respective *Journals* and *Transactions.* These discussions show the obstacles in the way of applying automatic temperature control to furnaces where gradients exist, making it difficult to select the one location where the temperature is representative and where at the same time it is indicative of both changes in *demand* and effects of changes in supply.

*As a matter of fact, some of these—especially those that come within the jurisdiction of and comply with the various electrical and mechanical standards sponsored by the A.I.E.E., N.E.M.A., N.E.L.A., Underwriters' Laboratories—are better designed, better constructed, operate better and sometimes necessarily cost more than some of the simpler forms of industrial heat regulators.

located at the point of application and those with connecting tubes or leads running from the bulb or couple to another element of the system; or else the distance feature may refer to the operation of a valve at a distance from the instrument case which may be located on a panel board.

One logical classification is into self-operating instruments or appliances or *devices;* and control *systems* which utilize relays. By "self-operating" is meant that the primary element responds to temperature with sufficient force to operate a valve, damper, etc., for controlling temperature. If the primary element actuates a pilot valve or a contact, the controller belongs to the relay class. The "instrument" proper forms part of a hook-up which must be considered as a whole: the instrument *commands* the power which *controls* the heat supply and hence the temperature.

This suggests a classification according to form of power. Such forms will be discussed below but it will be hard to follow a definite classification because some systems would belong to two and even three classes. For example, a primary element ma yactuate an air valve relay which actuates an electric relay which in turn commands the energized device.

"The energized device"—this does not mean the valve or damper but the *power device* or *power unit;* and here we have still another basis for classification: Diaphragm, solenoid, cylinder-and-piston, electric motor, etc.

The Power Device or Unit is the "muscle" of any *relay type* of automatic controller commanding an element such as a valve or rheostat which requires expenditure of energy for its positioning, operation, etc. (in a self-operating controller the power device is *not* a distinct element.) Examples of power devices or units are electric, pneumatic or hydraulic servo-motors, pneumatic diaphragms, etc. The power device or unit is to be distinguished from the final control element. The common terms "control valve," "diaphragm-motor valve," etc., denote the *combination* of a power device and a control*led* element. For example, in a "control valve" of the diaphragm type, the power device is the pneumatic diaphragm "top" and the controlled element is the valve proper.

And last but not least, a classification of the valves and other medium-controlling appliances. Certainly not least, because this final element of the temperature control system often determines the choice of the others.

To tabulate all the possible combinations in a comprehensive and systematic way would be both tedious and useless. An idea of the number of possible hook-ups may be had by multiplying the number of types of primary elements (about 20) by one-quarter of the number of classes of relay methods (about 8*), multiplying the product (about 40) by one-quarter of the number of forms of power devices (about 20) and multiplying this product (about 200) by one-quarter of the number of varieties of finally operated valves (about 400). We get something like 20,000 possible combinations, and only one-quarter of the number was used at every step of this process.

Or, to put it in another way, you may start with any one of the 20-odd types of primary elements, have it actuate one of a choice of two (out of 8) relay systems, then select any one of five (out of 20) power devices capable of operating any one of 100 (among 400) valves.

Omitting the valves we have the conservative number of 200 wholly different types of automatic temperature controllers. We could even call them classes because they would all be mutually exclusive. And all this without mentioning the possibilities in the way of direct and reverse action at each step—which gives us $200 \times 2 \times 2 \times 2 = 1600$.

Ordinary self-operating controllers, those combined with valves, cannot strictly meet the Fourth Requirement (see Section 4) but the effort exerted by their combination measuring-and-operating elements is minimized by the use of balanced valves, etc., and their applications still outnumber the applications of all relay control systems. The most important process-control applications, however, require the use of relay types, some of them with elaborate amplifying systems whereby the moving element of the measuring system

*Seven classes if we include "steam" with "pneumatic," eight if it is recognized as a class by itself.

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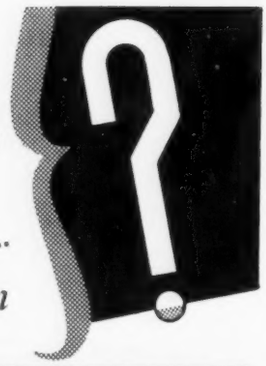

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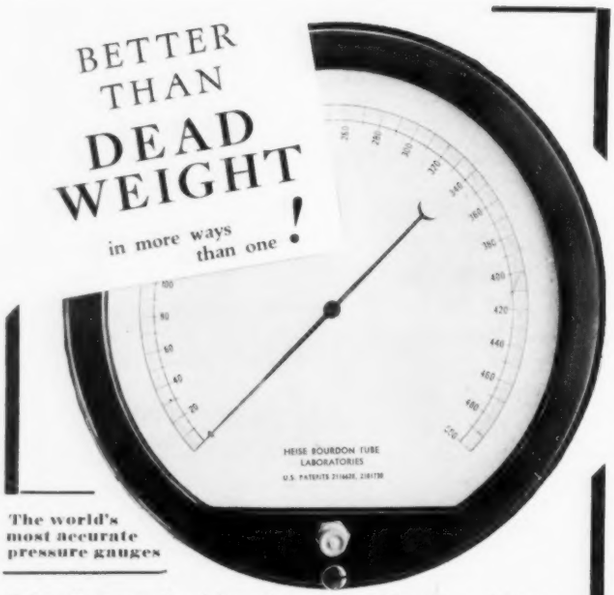

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An obvious solution of the drag problem is exemplified in those controllers (both self-operating and relay) in which the measuring system has no moving parts at all. This leads to the following classification of all automatic control systems according to *temperature measuring systems:*

Class I. Kinetic (or Dynamic)	All measuring systems in which variations in the controlled temperature are represented by mechanical displacements.
Class II. Static	Saturable magnetic circuits. Electronic devices. Circuits utilizing non-linear resistances.

Another solution consists in the elimination of moving parts from the power unit (e.g., by use of electronic devices) as exemplified in various temperature controllers for electrically-heated processing apparatus.

An ideal solution (not *the* ideal, because of various shortcomings such as absence of adjustment dials and other process-control conveniences) is to have no moving parts in the measuring system, in the control means or in any other element of the automatic controller.

6. "Sensitivity" and "Sensitiveness."

Perfect automatic control may be said to be an unattainable ideal for the reason that a controller only starts correcting when a correction has to be made. Suppose an electrical relay controller set for "700 degrees." So long as the temperature is "exactly 700," the controller remains inoperative, and no command is transmitted from the controller to the motorized valve.* Not until a deviation from the normal condition of "exactly 700°" occurs need the controller act. Furthermore, the controller is so designed that it will not act until a deviation occurs. Finally, the controller will not act until its primary system responds to a measurable deviation. In other words the normal condition of "exactly 700°" is in reality 700° plus or minus the departure which causes the controller to act. This performance characteristic is true of all temperature controllers. The sensitivity of the primary system of an automatic controller thus emerges as a most important factor: an important *property* of the measuring system manifesting itself as an important *operating characteristic* of the control instrument.

It is generally necessary to distinguish between the sensitivity of the primary system and the corresponding characteristic of the control instrument, for two reasons: (1) that a small change may displace the pointer (or equivalent element) of the primary system of many widely employed forms of control instruments without causing any correction to be made; and (2) that while the sensitivity of the primary system is seldom variable at will, that of the controller may be adjusted. For example, the primary system of a particular electric-contact type temperature controller, *considered as a measuring instrument*, has a unit sensitivity of 5°F. so that a change of 5°F. will cause a displacement of 1 mm. at the tip of its pointer, but the controller may purposely have been set with "high" and "low" contacts separated by an angle corresponding to 20°F. To the question "what is the sensitivity of this thermostat?" there cannot be a simple answer. One might express the unit sensitivity of the primary system as 5°F. or express the ultimate sensitivity of the primary system as 2°F. (see Chap. II, Sec. 2) One might state on the other hand that while the controller is now set for 180° with high contact at 190° and low contact at 170°, it could be set for a smaller or a greater differential, the limits imposed by its design being, say, 10° for the smallest differential and 100° for the greatest.

This example illustrates both that the ultimate sensitivity of the primary element may not always be *utilized*, and that the minimum change causing corrective action by the controller is an always *greater* amount, which however may be varied at will in some designs.

*We purposely take the case of an electrically operated controller that literally *does nothing* when the controlled condition is correct. In the case of an air-operated controller, the constant flow of air suggests a continuous activity on the part of the controller which is irrelevant to the illustrative argument.

In this example of a contact thermostat it has been assumed for the sake of simplicity that whenever either the "high" or the "low" contact circuit is closed the controlled supply valve will be positively operated, so that it was not necessary to take into account the operation of the valve-operating mechanism. In the case of some other controllers the minimum departure necessary to cause motion at the instrument end of the primary system may not be sufficient to cause a change in the position of the controlled heat-supply valve. This is generally true of multi-element automatic controllers.

We may then make a distinction between the ultimate sensitivity of the control instrument and the minimum change which will cause a greater or smaller flow of the controlled medium, or otherwise cause effective action at the point of control. This performance characteristic of the control system *as a whole* is called Sensitiveness.*

The sensitiveness of a controller is expressed in degrees of temperature, as is the ultimate sensitivity of a temperature measuring instrument, but it is a different thing. Ultimate sensitivity has to do with a change of value anywhere within the scale range of a measuring instrument, but sensitiveness has to do only with changes in the region of the setting point. Ultimate sensitivity is usually a definite minimum amount of change in the measured temperature while sensitiveness is the sum of two amounts: one representing the ultimate sensitivity of the measuring system and the other representing the additional change in the controlled temperature necessary to cause effective action at the point of control. To illustrate this important difference we may consider an automatic temperature controller consisting of the following:

A. The primary measuring system which we may call the thermometer.

B. A remote reading system consisting mainly of a transmitter actuated by the thermometer and a panel board receiving instrument with setting dial for automatic control;

C. A relay system for energizing the power device;

D. The power device consisting of a reversing motor with limit switches and other usual accessories; and finally

E. The controlled valve operated by the power device.

Without going into details it is obvious that

1. The ultimate sensitivity of the measuring system is the change in temperature which will cause effective motion at the thermometer end.

2. A greater change is required to cause, at the panel board instrument, observable displacement of the pointer or pen arm or effective actuation of the prime relay.

3. The controlled temperature may fluctuate over a zone greater than the value of the ultimate sensitivity of the measuring system, without causing any relay to be actuated. This holds true even for the case that the controller is set for "point control" and not for "high and low."

4. As long as no relays are actuated and the controller remains inoperative, the controlled temperature is *normal.*

5. Normal temperature does not have a single value as does a "point."

6. The controller's sensitiveness is the width of this zone.

Let us now assume that the ultimate sensitivity of the measuring system (when the temperature is around 500°) is 2° and that the sensitiveness of the controller is 5°. We then have a controller "sensitive to" 5°. In the event that its working range is 0-1000° it may be said to be "sensitive to one-half percent of working range." If its setting range is 400 to 600° it may be said to be "sensitive to 2½%."

In any case, it is plain to see that in addition to the distinction between sensitivity and sensitiveness, there is a distinction between setting point and normality. Normality is not a point but a zone or range.

Set for point control at 500°, this controller will perform a corrective function whenever a change of 5° occurs. Assuming that the entire installation is such that corrective action is always effective, the temperature will never drop for long below 495° nor exceed for long 505°. Moreover, if the installation is correct, the controller will settle down to

*This is in harmony with the A.S.M.E. Power Test Codes, which use "sensitivity" for the property of instruments in the Instruments and Apparatus Code and "sensitiveness" for the performance characteristic of "the complete speed-responsive regulating mechanism" in the Code for Speed-Responsive Governors.

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The Alnor is a simplified controller which operates on an electronic principle similar to a radio.

The pointer of the pyrometer carries a vane. Two similar condenser vanes are attached to the arm of the adjustable target. When the pyrometer pointer reaches the target setting, the pointer vane passes between the condenser vanes and causes a change in the capacity of the circuit which in turn actuates the switch controlling the heating current or fuel valve. A red eye tells whether the heat is on or off.

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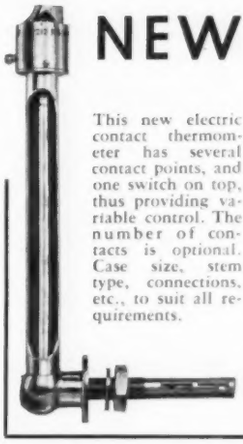

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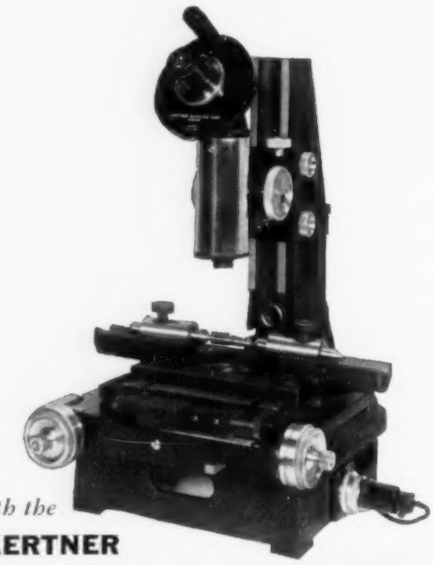

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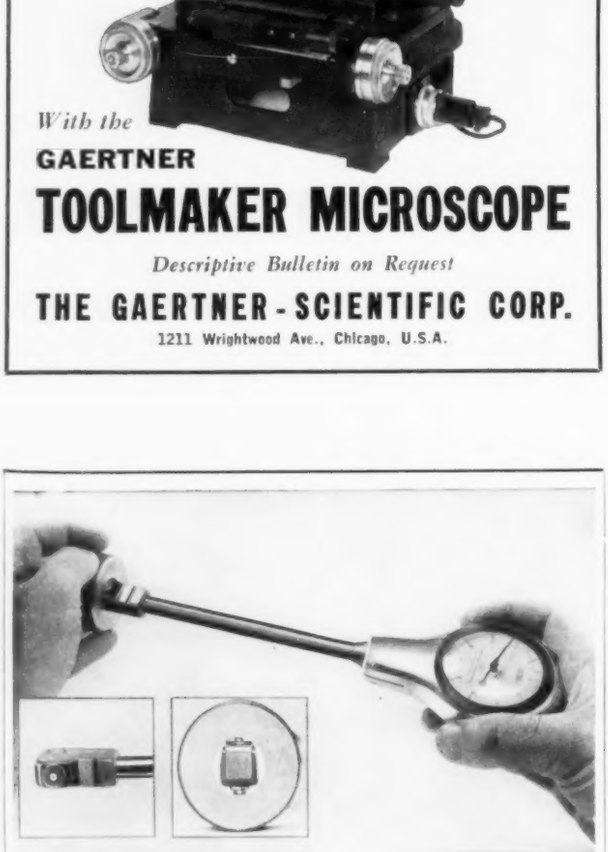

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the state where it functions at 497.5° and 502.5°. Normality in this case, is not identical with the setting point of 500 but is the 5° zone between 497.5° and 502.5°.

But this same controller—and this is true of many industrial controllers—may be adjusted to make contacts at 480° and 520° in order to save wear and tear on the power device, control valve and other accessories. Normality will then be a zone of 40°. The *actual sensitiveness* of the controller will be 40°, but the available sensitiveness, as could be determined in a test, will nevertheless remain 5°. And, of course, the sensitivity of the measuring system will remain 2°.

Now let the instrument-using reader imagine himself in the position of the instrument maker. It is a ticklish business to guarantee that the controller *will* maintain temperature within a maximum variation of ±5°, because the results obtained with any controller depend on the installation as a whole, including the application factors external to the controller. It will be simpler to overlook the difference between sensitivity and sensitiveness and, knowing that the thermometer has an ultimate sensitivity of 2°, to advertise that the controller is "sensitive to 2°." This common practice of controller manufacturers is not due to shrewd taking advantage of the fact that the adjective for both sensitivity and sensitiveness is "sensitive" but it is due to the greater convenience and desirability of considering the limitations of the measuring system.

On the whole, the general figure of merit of a control system is necessarily determined by that of its primary elements. Other things equal, a temperature controller with a measuring system the ultimate sensitivity of which is 2°F. will be capable of closer control than another controller having a measuring system the sensitivity of which is 10°F. It is by no means unethical for a manufacturer to state that his control pyrometer is "sensitive to a change of 2° in the furnace temperature"—and it is highly informative. It is a mark to shoot at in applying such a controller to a furnace.

"Sensitiveness," "normality" or "differential"—these standard Instrumentation terms are correct, both technically and in their implication. Some engineers in the employ of controller manufacturers use "dead zone"—which is bad because it sounds bad. At present (1932), instrument-department heads and other industrial experts wisely resist its introduction. Once they (the buyers) start using it when talking to manufacturers' engineers, they (the ones who now propose it) will be put on the defensive by the bad sound of this term. Some of them will then say: "Oh, but *our* controller has *no* dead zone!" It will be proved later that there is no such thing as an automatic temperature controller without dead zone. Since no temperature in industry need be maintained within a millionth of a degree, there is in every process a zone of normality. To maintain this normality, the controller has a corresponding normality or differential or sensitiveness of its own. That's all users want, but put "dead-zone" in their mouth and they'll want that which is as unattainable as . . . well, as measuring an industrial temperature closer than the International Temperature Scale.

In no case, of course, can a controller react to a departure smaller in value than the value of its sensitiveness. But—as the reader knows full well—this does not mean that a controller effectively sensitive to a given amount of change in the controlled temperature will necessarily be capable of controlling this condition within limits of departure equal to the value of such sensitiveness. In most cases the reason is that the installation does not meet the second and third of the Four Requirements stated in Sec. 4 but even when these requirements are satisfactorily met, we often find the record of the controlled temperature to be of the "saw tooth" variety with the difference between peaks and valleys many times greater than the departure from normality which makes the controller operate to effect a correction.

When we analyze installations we always find the causes of unsatisfactory control to involve *time elements*: "lags," "periods" and "delays." There never is any exception!

(To be continued)

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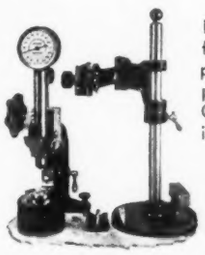

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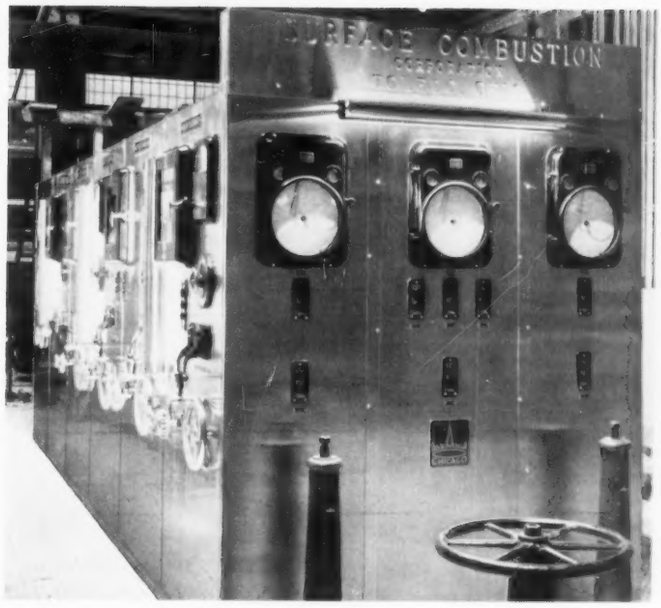

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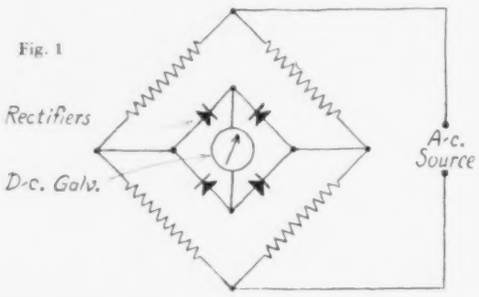
Adapting a D-c. Galvanometer to an A-c. Bridg

By PHILIP EWALD
Sheffield, Ala.

ALTERNATING-CURRENT BRIDGES are frequently used in making measurements of inductance, capacitance, conductivity of solutions, and even straight resistance. A suitable a-c. galvanometer for detecting bridge balance is sometimes difficult to obtain and often troublesome to adjust. A d-c. galvanometer may be used as a balance detector if rectifiers are used in the circuit. When these rectifiers are connected in the conventional manner (as shown in Fig. 1) the galvanometer will show the null point, but not the direction of unbalance of the bridge. Such an arrangement is unhandy in the case of a manually-balanced bridge; and it is useless where automatic balancing is involved as in a recorder, or an automatic controller.

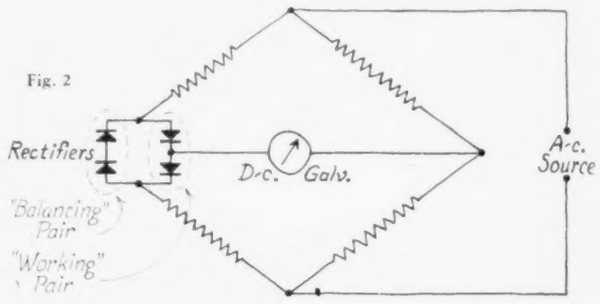
Fig. 1



The problem may be eliminated by putting the rectifiers into the circuit in the manner shown by Fig. 2. With this circuit, the galvanometer will deflect in the direction of unbalance of the bridge.

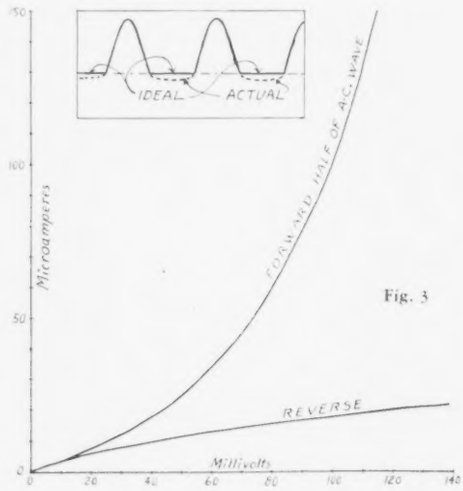
The inside pair of rectifiers does the actual work of directing the current. The outside pair merely acts to balance the resistance of the first pair. Thus, no matter in which direction the current flows in the bridge, the total rectifier resistance is the same. This allows a symmetrical a-c. wave in the bridge, necessary for some measurements.

Fig. 2



This bridge is subject to limitations imposed by the available rectifiers. The ideal rectifier would have no resistance at all on the forward half of the a-c. wave and infinite resistance on the reverse half. Unfortunately, there is no such rectifier. Vacuum tubes might be used for special cases, but have too high a resistance for ordinary use, and suffer from the complication that a filament has to be heated. Electrolytic rectifiers are too unstable to be practical. Copper oxide rectifiers offer the best answer and give satisfactory operation. The characteristic of a 50-milliampere rectifier in the low-current range is shown in Fig. 3. As may be seen from the curved graphs, the rectifier resistance varies with the current through it. Since changing currents change effective rectifier resistance, it is important that the voltage to the bridge be maintained constant.

Fig. 3



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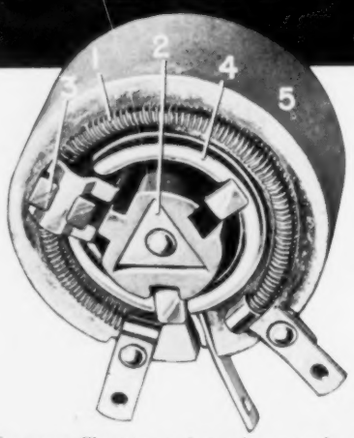

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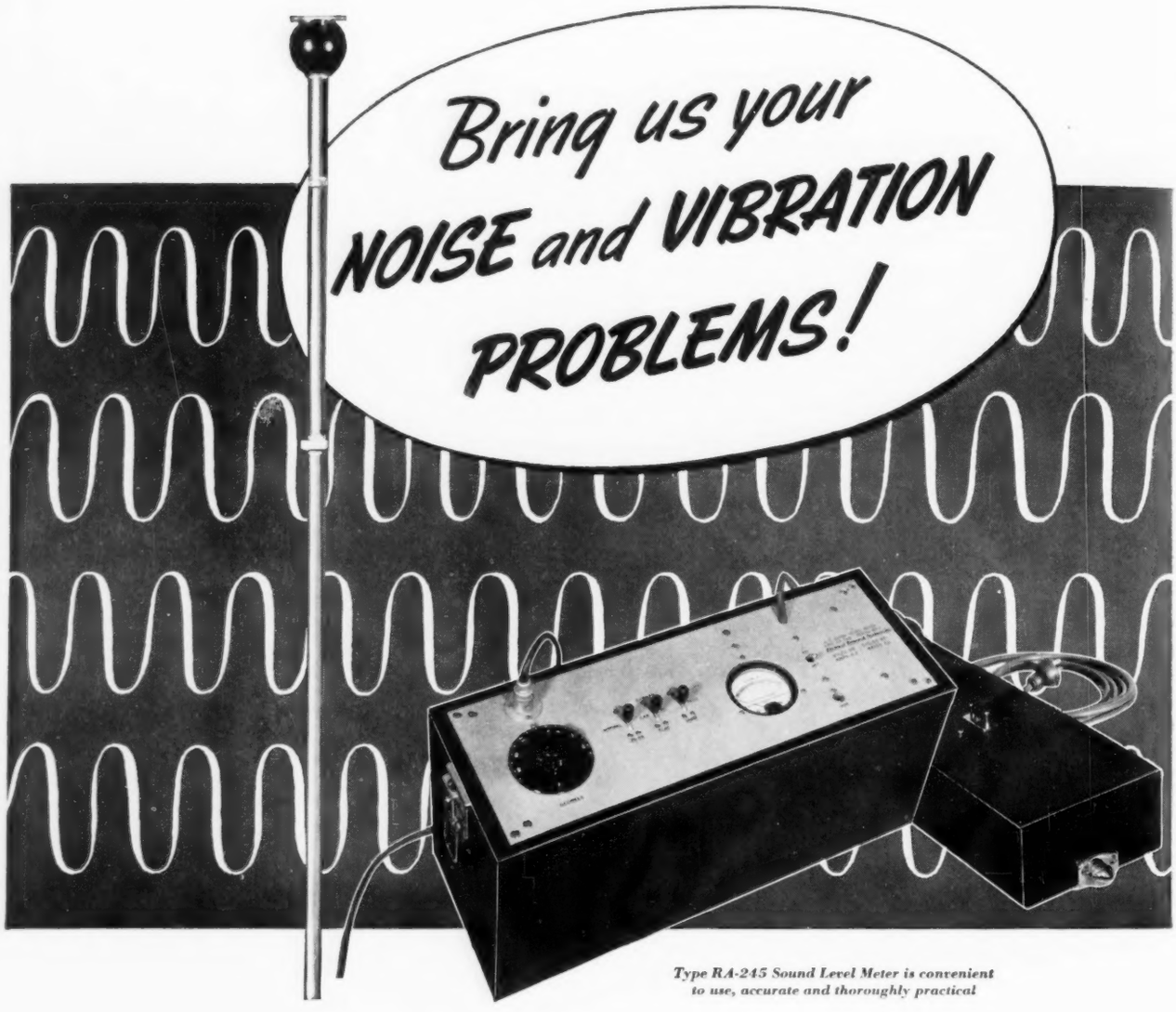
SPECIAL ISSUE :: :: IN TWO PARTS

PART TWO

THE 1940 Instruments INDEX



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January, 1940
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Instruments THE MAGAZINE OF MEASUREMENT and CONTROL

PART TWO—THE 1940 INSTRUMENTS INDEX

More Than a Directory

CONTAINING the answers to 99% of the inquiries which *Instruments* receives from subscribers, this Supplement may be likened to a set of phonograph records: it can only be "played" by a "pick-up." The simple "pick-up," which will place at your instant command a wealth of information, is merely your getting acquainted with this Supplement by READING THIS PAGE.

The Index Section—"who makes what"—is the most important. Anyone who wants to know where he can buy or secure information on a certain product will find the product properly indexed and cross-indexed, and under it the names of the manufacturers and sole representatives.

Indexing System. Products are indexed under the main word. In cases where a name is ambiguous, or where the item is known under two or more names, companies making such devices are listed under one subject and cross-references inserted under the other headings.

Specific Terms. You never are in need of "a gage" but of some particular kind of gage. Therefore we do not list manufacturers under broad general designations. For example, we do not list any names under the main heading "Meters" but we give the sources of supply for numerous classes and types of meters. Moreover, we do not list any names under "Meters, Liquid" alone, but we give under proper subheads the sources of supply for the *class* and *type* of liquid meter you may need.

Trade Names. An effort has been made to remove all proprietary trade names from the Index Section.

Correctness of Headings. As explained above, main headings and sub-heads are technically correct. A few are not scientifically correct: they are names in common usage, recognized for the convenience of the majority.

Correctness of Listings. We have endeavored to list no firm names under specific headings unless the instruments made by such firms belong there by virtue of their design and construction.

For example, instruments called "colorimeters" but which cannot yield color specifications, belong under Color Comparators, Color Matchers, etc.

Also, an instrument called the "Integrating ———" or "Totalizing ———" may be nothing but a counting type, belonging under the sub-head "Counting."

This we have done in relatively few cases, for it amounts to *censoring* the data sent to us by manufacturers (or sole representatives). As a rule, we had to take the company's word that it could supply the product in question. We can't send "detectives" to a thousand plants!

Completeness. More than 1000 manufacturers were convassed in the last four months. Those that did not fill in our first questionnaire after one month received a second one. Again, a third questionnaire was sent to non-responders at the end of the second month. In the last few weeks we even sent representatives to call on manufacturers. Therefore, the omission of any manufacturer's name under any heading is due to the negligence of someone in his own organization.

Every effort has been made to restrict the names in the Index Section to (1) the actual manufacturers and (2) the sole authorized sales agencies. On the other hand, whenever you desire to order at one time a variety of equipment, made by different firms, you may find it most convenient to get in touch with a recognized, competent, "laboratory supply house." These houses are listed under "*Apparatus, Laboratory*," on page 3.

Directory of Manufacturers (and Sole Representatives). This Section, pages 56-64, has a new feature this year: descriptions of the lines made or sold by these companies. We have added this feature because many of our subscribers, before writing to sources of supply, ask us "What kind of an outfit is the ——— Company?" Of course we have no right to qualify any company; and we never did.

In previous years, for example, a subscriber would find listed, under the item he wanted to buy, AAA Co., BBB Co. and CCC Inc., and would *later* discover that AAA Co. specialized in foundry supplies, BBB Co. manufactured chemical apparatus and CCC Inc. sold mill supplies. Now, every user of this directory can get a general idea of "the kind of an outfit." We have made every effort to obtain, from every manufacturer and supply house, a brief but adequate self-description.

Instruments' Further Service. This Index contains the answers to *only* 99% of your inquiries. If you cannot find the product or the name you want, communicate with the Information Section, Instruments Publishing Co., 1117 Wolfendale St., Pittsburgh, and every effort will be made to furnish the information promptly.

Suggestions. We shall appreciate suggestions regarding:

1. Headings not at present found in this Index which should be there,
2. Firms listed erroneously, and
3. Other inaccuracies which may have crept in despite all precautions.

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2. List of the Laboratory Supply Houses. Under the heading "Apparatus, Laboratory," on page 3, are listed companies specializing in laboratory supplies, equipment, instruments and apparatus.

3. Directory of Manufacturers and sole representatives, with complete addresses and brief descriptions. *Pages 56-64.*

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R. RIMBACH Managing Editor
M. F. BEHAR Editor

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Burton-Rogers Co.
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Welch Mfg. Co.
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AMMETERS, Surge-Crest
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AMMETERS, Thermo
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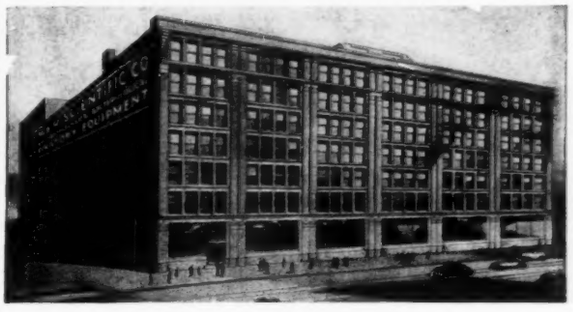

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Heusser Instrument
Microchemical Service
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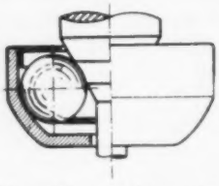

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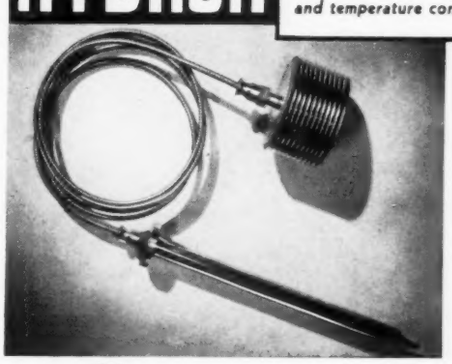

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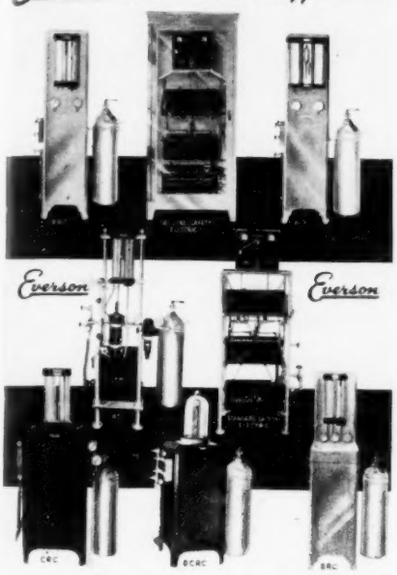

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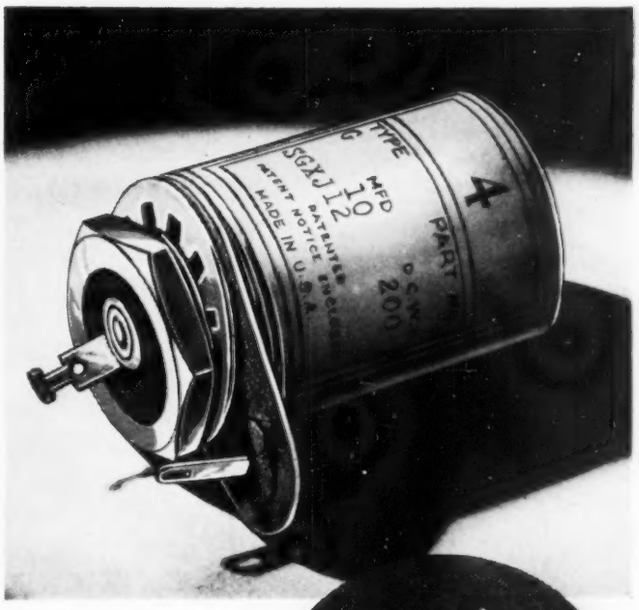

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Humboldt Mfg. Co.
Ruehfel Co.
Scientific Inst. Co.
Tagliabue Mfg. Co.
Western Machinery Co.

COAL METERS
Bailey Meter Co.
Northern Equip. Co.

COIL TESTING EQUIPMENTS (See Testers, Coil)

COLLIMATORS, Vertical
Pecker, J. W.
Pioneer Instrument Co.
White Co. Inc.

COLOR ANALYZERS, Photoelectric
Akatos, Inc.
Bausch & Lomb Optical
Central Scientific Co.
Elmer & Amend
Electronic Laboratory
Electronic Prod. Co.
Ess Inst. Co.
Fisher Scientific Co.
Gaertner Scientific Corp.
General Elec. Co.
General Radio Co.
Hays Laboratories
Klett Mfg. Co.
Lux'rol Co., Inc.
Pfaltz & Bauer, Inc.
Photobell Corp.
Rawson Elec. Inst. Co.
Rubicon Co.
Saxl Instrument Co.
Sheldon Electric Corp.
United Cinephone Corp.
Woermann-Schuchhardt

COLOR COMPARATORS, Photoelectric (See Color Analyzers, Photoelectric)

COLOR COMPARATORS, Visual
Akatos, Inc.
Baird Associates
Bausch & Lomb Optical
Central Scientific Co.
Electronic Research Labs.
Fisher Scientific Co.
Gaertner Scientific Corp.
Hays Laboratories
Hellige, Inc.
LaMotte Chemical Prod.
Leitz, Inc.
Luxtrol Co., Inc.
Munsell Color Co.
Rascher & Betzold
Saxl Instrument Co.
Tagliabue Mfg. Co.
Taylor & Co., Inc., W. A.
United Cinephone Corp.
Zeiss, Inc., Carl

COLOR GRADERS (See Color Analyzers, Photoelectric)

COLOR MATCHING OUTFITS (See Color Comparators, Visual)

COLORIMETER TUBES (See Colorimeters, Visual)

COLORIMETERS, Photoelectric
American Inst. Co.
Central Scientific Co.
Electronic Prod. Co.
Frober-Faybor Co.
General Elec. Co.
Hays Laboratories
Higgins, Charles F.
Klett Mfg. Co.
Luxtrol Co., Inc.
Pfaltz & Bauer, Inc.
Photobell Corp.
Rubicon Co.
Saxl Instrument Co.
Scientific Glass App.
United Cinephone Corp.
Woermann-Schuchhardt

COLORIMETERS, Visual
Akatos, Inc.
American Inst. Co.
Bausch & Lomb Optical
Central Scientific Co.
Electronic Research Labs.
Fisher Scientific Co.
Klett Mfg. Co.
Leitz, Inc.
Munsell Color Co.
Rascher & Betzold
Saxl Instrument Co.
Spencer Lens Co.
Tagliabue Mfg. Co.
Zeiss, Inc., Carl

COMBUSTION Indicators and Recorders (See Gas Analyzers, Boiler Meters, etc.)

COMBUSTION CONTROL EQUIPMENT (See Controllers, Automatic-Combustion)

COMMUNICATION MEASURING INSTRUMENTS
American Automatic Elec.
Andrew, Victor J.
Ballantine Labs.
Bernard, H. J.
Brush Development Co.
Clough-Brengle Co.
Daven Co.
Elec. Indicator Co.
Ferris Inst. Corp.
General Elec. Co.
Hickok Elec. Inst. Co.
Industrial Inst. Inc.
Jones-Orme Co.
Leeds & Northrup Co.
Microvolts, Inc.
RCA Manufacturing Co.
Rubicon Co.
Sensitive Research Inst.
Shallcross Mfg. Co.
Weston Elec. Inst. Corp.

COMPARATORS, Mechanical
Federal Prod. Corp.
Ferner Co.
Mico Instrument Co.
North Side Tool Co.
Scherr Co., Inc.

COMPARATORS, Optical
Bausch & Lomb Optical
Cambridge Inst. Co.
Electronic Research Labs.
Ess Inst. Co.
Jones & Lamson Mach.
Leitz, Inc.
Scherr Co., Inc.
United Cinephone Corp.
Van Keuren Co.
Zeiss, Inc., Carl

COMPASSES, Aircraft
American Askania Corp.
Elgin Natl. Watch Co.
Kollsman Inst. Co.
Moisture Register Co.
Pioneer Instrument Co.
RCA Manufacturing Co.
Star Compass Co.

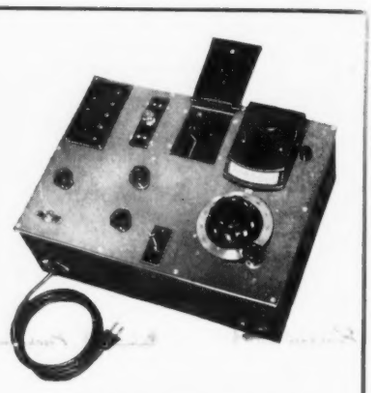

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PHOTO-ELECTRIC COLORIMETER

FOR ALL
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True Transmission Measurements
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Write for complete information and catalogs.

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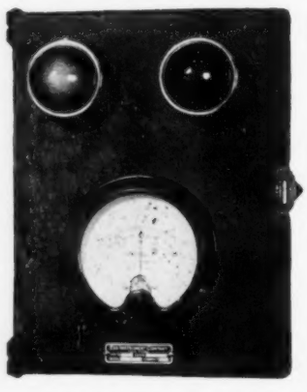


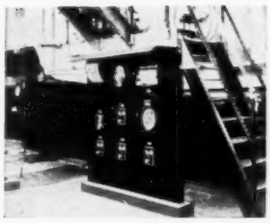
PRECISION COMBUSTION
REQUIRES INSTANTANEOUS, SENSITIVE, INFORMATION

The HAZEGAGE "Electric Eye" Combustion Indicator is the *fastest* instrument on many modern panel boards. It enables automatic controls to be set *more precisely*—often on ten-second information.

It *notifies* firemen when "out of bounds"

Ess Instrument Company
30 Irving Place, N.Y.C.

For addresses, see pages 56-64



BAILEY METER *Combustion* CONTROL

● Bailey Meter Automatic Combustion Control of boilers results in substantial saving in fuel; increased boiler capacity; reduction of boiler and furnace maintenance; more time for operators to devote to general station maintenance; and improvement in the general character of service.

Bailey Meter Control makes possible the everyday operation of boilers at test efficiencies because it is a complete combustion control system which (1) automatically maintains steam pressure by supplying fuel and air simultaneously to boilers in accordance with changes in steam demand, (2) automatically maintains most economical fuel-air ratio by incorporating the Bailey Boiler Meter as an integral part of the system, (3) automatically maintains the desired furnace draft, and (4) automatically distributes load among boilers so that each unit carries its share.

This sturdy inexpensive air-operated control system has been applied to all sizes and types of boilers ranging from 200 h.p. upward. It is applicable to all fuels and all methods of firing.

For further information consult Sweet's Engineering Catalogs or write for bulletin No. 102-A.

BAILEY METER COMPANY
1041 IVANHOE ROAD · CLEVELAND, O.
Bailey Meter Company Ltd., Montreal, Canada

A 24-HOUR RECORD—giving accurate and dependable measurements so vital to efficient and economical operation.

Hays Combustion Meters employ the Orsat principle for measurement of CO_2. Water operated — no moving parts—extreme accuracy coupled with dependable performance.

There is a Hays Combustion Meter to fit every requirement—remote or integral mounting, indicating or recording or both. Write to 925 Eighth Avenue, Michigan City, Indiana, for free catalog.

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Star Compass Co.
U. S. Gauge Co.

COMPASSES Azimuth
Ainsworth & Sons
Keuffel & Esser Co.
Leupold, Volpel & Co.
Pioneer Instrument Co.
Warren-Knight Co.

COMPASSES, Dip
Gurley, W. & L. E.
Keuffel & Esser Co.
Taylor Inst. Cos.
Warren-Knight Co.

COMPASSES, Drafting Room (See Drawing Instruments)

COMPASSES, Gyro
Sperry Gyroscope Co.

COMPASSES, Magnetic
Ainsworth & Sons
Baker Compass Co.
Geophysical Inst. Co.
Gurley, W. & L. E.
Keuffel & Esser Co.
Kollman Inst. Co.
Leupold, Volpel & Co.
Negus, T. S. & J. D.
Pioneer Instrument Co.
Star Compass Co.
Taylor Inst. Cos.
Tesdrite Instrument Co.
Warren-Knight Co.

COMPASSES, Marine
American Askania Corp.
Baker Compass Co.
Bendix Marine Products
Bilas & Co.
Geophysical Inst. Co.
Marine-Compass Co.
Negus, T. S. & J. D.
Star Compass Co.

COMPASSES, Radio
Hickok Elec. Inst. Co.
RCA Manufacturing Co.
Triumph Mfg. Co.

COMPASSES, Ship (See Compasses, Marine)

COMPASSES, Telltale (See Compasses, Marine)

COMPENSATION, Magnetic
Geophysical Inst. Co.

COMPOSING TYPEWRITERS
Coxhead Corp.

CONDUCTION RECORDERS
Leeds & Northrup

CONDENSER, Electric (See Capacitors)

CONDENSER LEAKAGE, Indicators
Associated Research
Clough-Brengle Co.
Electronic Design Corp.
Hickok Elec. Inst. Co.
Industrial Inst. Inc.
Jackson Electrical Inst.
Leeds & Northrup Co.
Potter Co.
Radio City Products Co.
Rawson Elec. Inst. Co.
Tobe Deutschmann Corp.
Triumph Mfg. Co.
Weston Elec. Inst. Corp.

CONDENSER LEAKAGE, Recorders
Esterline-Angus Co.
Leeds & Northrup

CONDENSER TESTERS (See Testers, Condenser)

CONDUCTIVITY METERS
Allis-Chalmers Mfg. Co
Central Scientific Co
Coleman Electric Co.
Electronic Prod. Co.
Esterline-Angus Co.
Industrial Inst. Inc.
Leeds & Northrup Co.
Natl. Aluminate Corp.
Rubicon Co.
Sensitive Research Inst.
Shallcross Mfg. Co.

CONES, Pyrometric
Accurate Pyrometric Cone
Fish-Schurman Co.
Henderson & Co.
Orton Jr. Ceramic F'd'n

CONES, Slump
Central Scientific Co.
Humboldt Mfg. Co.
Precision Scientific Co.
Riehle Div.

CONNECTORS, Plugs, Clips, Posts, Jacks
Am. Automatic Electric
American Inst. Co.
Autocall Co.
Eby, Inc.
General Radio Co.
Kellogg Switchboard
Meter Devices Co.
Shallcross Mfg. Co.

CONSISTENCY REGULATORS, Pulp & Paper (See Controllers, Automatic, Consistency)

CONSTANT SPEED and Frequency Sets
Andrew, Victor J.
Elec. Tachometer Corp.
Gaertner Scientific Corp.
General Elec. Co.
United Cinephone Corp.
Westinghouse Elec. & Mfg.

CONTOUR MEASURING PROJECTORS
Bausch & Lomb Optical
Leitz, Inc.
Scherr Co., Inc.

"CONTROL" — NOTE —

The following pages deserve close study. Note for example that after numerous "Controllers, Automatic" there are three classes of "Controllers, Manual." Look up also under "Regulators" for many types thus termed by usage. Also "Thermostats" and other commonly-used names of specific-purpose automatic controllers.

As a rule, Automatic Controllers are "instrument-like" while devices known as Controls (preceded by name of application) are simple, single-purpose devices.

CONTROL DRIVES (See Servo-Motors)

CONTROLS, AUTOMATIC (See Controllers, Automatic)

CONTROLLERS, AUTOMATIC (See also object of Measurement and Control)

CONTROLLERS, AUTOMATIC, Ammonia (See Ammonia Control Equipment)

CONTROLLERS, AUTOMATIC, Beater (See Controllers, Automatic, Consistency)

CONTROLLERS, AUTOMATIC, Boiler Feed
Atlas Valve Co.
Bailey Meter Co.
Consol. Ashcroft-Hancock
Foster Engg. Co.
Foxboro Co.
Hagan Corp.
Henszey Co.
Kiely & Mueller
Mason-Neilan Regulator
McDonnell & Miller
Mercon Regulator Co.
Natural Gas Equipment
Northern Equip. Co.
Republic Flow Meters Co.
Robertshaw Thermostat
Ruggles-Klingemann
Watts Regulator Co.
Wilgus Mfg. Co.

CONTROLLERS, AUTOMATIC, Boiler Water Concentration
Cochrane Corp.
Henszey Co.
Leeds & Northrup Co.
Republic Flow Meters Co.
Fischer & Porter

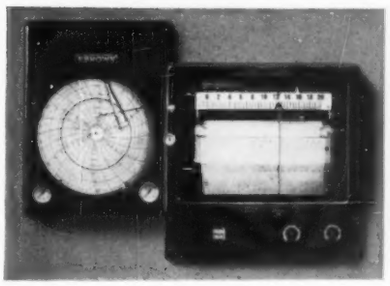
CONTROLLERS, AUTOMATIC, Bulk Material Level
Bin-Dicator Co.

CONTROLLERS, AUTOMATIC, Chlorine
Arca Regulators, Inc.
Askania Regulator Co.
Builders Iron Foundry
Everson Mfg. Co.
LaMotte Chemical Prod.
National Meter Co.
Rascher & Betzold
Victor Equipment Co.
Wallace & Tiernan

CONTROLLERS, AUTOMATIC, Combustion
Arca Regulators, Inc.
Askania Regulator Co.
Bailey Meter Co.
Brooke Eng. Co.
Brown Inst. Co.
Cambridge Inst. Co.
Cash Co.
Consulting & Engineering
Crew Equip. Co.
Defender Automatic Reg.
Denver Fire Clay Co.
Electronic Prod. Co.
D'Este Co.
General Combustion Corp.
General Regulator Corp.
Hagan Corp.
Hays Corp.
Lammert & Mann Co.
Lantz-Phelps Corp.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
National Airoil Burner
National Brass Co.
Natural Gas Equipment
Paragon Electric Co.
Penn Electric Switch Co
Partlow Corp.
Republic Flow Meters
Ruggles-Klingemann
Selas Company
Wilgus Manufacturing

CONTROLLERS, AUTOMATIC, Condensation
Bailey Meter Co.
Boylston Co.
Fisher Governor Co.
Friez & Sons
General Regulator Corp.
Industrial Instrument Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.

CONTROLLERS, AUTOMATIC, Condenser Leakage
Leeds & Northrup Co.



BROWN CONTROLLERS

Electric or Air-Operated Types

Brown instruments are supplied as electric or air-operated controllers, complete with valves, motor mechanisms and relays, for automatically controlling temperatures, pressures, flows, liquid levels, humidity, etc. Instruments indicate or record while they control power plant or industrial processes. Write for Catalog 8902.

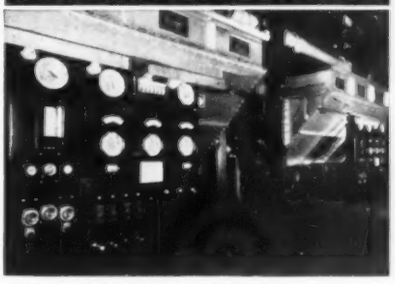
Brown Pneumatic Remote Transmission System

For remote transmission of measurement and control of temperatures, pressures, flows and liquid levels in hazardous atmospheres. Write for Bulletin 94-3.

THE BROWN INSTRUMENT COMPANY, *a division of Minneapolis-Honeywell Regulator Co.*, 4482 Wayne Avenue, Philadelphia, Pa.

BROWN INSTRUMENTS
AND
MINNEAPOLIS-HONEYWELL CONTROL SYSTEMS
To Measure and Control is to Economize

COMBUSTION CONTROL



All Sizes of Boilers All Types of Firing

Republic-Smoot combustion control systems are designed for all sizes of boilers and all types of fuel firing equipment.

CONSTANT STEAM PRESSURE
Automatically maintains a constant steam pressure by controlling the fuel and air input to the boilers in balance with the boiler load.

EFFICIENT COMBUSTION
Automatically maintains maximum combustion efficiency over entire range of boiler rating, by controlling simultaneously the fuel and air input to boiler in measured proportions and in a fixed ratio.

LOAD DISTRIBUTION
Automatically distributes load equally among all the boilers, or the load can be distributed between the boilers as desired.

WRITE FOR DATA BOOK No. S-21

REPUBLIC FLOW METERS CO.
2249 DIVERSEY PKWY., CHICAGO, ILLINOIS

For addresses, see pages 56-64

Controllers FOR AUTOMATIC REGULATION OF TEMPERATURE, COMBUSTION, pH, ETC.

Micromax Electric Control for temperature, etc., consists of Micromax instrument with valve-drive and relay developed and engineered as a unit to provide speed, sensitivity and accuracy. Simple, easy to install, low in maintenance.

Metermax Combustion Control is a unit system which automatically proportions fuel and air for efficient combustion in boiler and industrial furnaces. Special controls for special problems. Information on request.

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Green, Arthur B.
Mason-Neilan Regulator
Merritt Engr. & Sales
Northern Equip. Co.

CONTROLLERS, AUTOMATIC, Counting
Bristol Co.
Eagle Signal Corp.
Industrial Instrument Co.
Inspection Machinery Co.
Lumenite Electric Co.
Standard Electric Time
United Cinephone Corp.

CONTROLLERS, AUTOMATIC, Current (See Regulators)

CONTROLLERS, AUTOMATIC, Cycle
Autocall Co.
Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Cramer & Co., Inc.
Denver Fire Clay Co.
Elec. Switch Corp.
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Hanlon-Waters, Inc.
Industrial Instrument Co.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
Monitor Controller Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.

CONTROLLERS, AUTOMATIC, Damper
Arca Regulators, Inc.
Askania Regulator Co.
Atlas Valve Co.
Bailey Meter Co.
Barber-Coleman Co.
Bristol Co.
Brooke Eng. Co.
Brown Inst. Co.
Cash Co.
Cook Electric Co.
Davis Reg. Co.
Denver Fire Clay Co.
Detroit Lubricator Co.
Electronic Prod. Co.
Foster Eng. Co.
Foxboro Corp.
Gleason-Avery, Inc.
Hagan Corp.
Hanlon-Waters, Inc.
Hays Corp.
Johnson Service Co.
Kiely & Mueller
Leeds & Northrup Co.
Mason-Neilan Regulator
National Airoil Burner
Natural Gas Equipment
Penn Electric Switch Co.
Powers Regulator Co.
Preferred Utilities Mfg.
Republic Flow Meters
Ruggles-Klingemann
Schade Valve Mfg. Co.
Spence Eng. Co., Inc.
Tagliabue Mfg. Co.
Watts Regulator Co.
White-Rodgers Electric
Wilgus Mfg. Co.

CONTROLLERS, AUTOMATIC, Density
Acme Regulator Co.
Arca Regulators, Inc.
Automatic Valve Control.
Lumenite Electric Co.
Mine & Smelter Supply
Tagliabue Mfg. Co., C. J.
Taylor Instrument Cos.

CONTROLLERS, AUTOMATIC, Desuperheat
Arca Regulators, Inc.
Askania Regulator Co.
Atlas Valve Co.
Bailey Meter Co.
Foxboro Corp.
Hagan Corp.
Leeds & Northrup Co.
Mason-Neilan Regulator
Mercon Regulator Co.
Northern Equip. Co.
Republic Flow Meters Co.
Spence Eng. Co., Inc.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Trerice Co.

CONTROLLERS, AUTOMAT'C, Draft
Arca Regulators, Inc.
Askania Regulator Co.
Atlas Valve Co.
Bailey Meter Co.
Barber-Coleman Co.
Boiler Room Equip.
Bristol Co.
Brooke Eng. Co.
Brown Inst. Co.
Cash Co.
Crew Equip. Co.
Denver Fire Clay Co.
Foster Eng. Co.
Foxboro Co.
General Regulator Corp.
Gleason-Avery, Inc.
Hagan Corp.
Hays Corp.
Leeds & Northrup Co.
Mason-Neilan Regulator
National Airoil Burner
National Brass Co.
Preferred Utilities Mfg.
Republic Flow Meters
Ruggles-Klingemann
Tagliabue Mfg. Co.
Taylor Inst. Cos.

CONTROLLERS, AUTOMATIC, Feed Water
Askania Regulator Co.
Atlas Valve Co.
Bailey Meter Co.
Consol. Ashcroft-Hancock
Hagan Corp.
Hanlon-Waters, Inc.
Hensley Co.
Kiely & Mueller
Mason-Neilan Reg. Co.
McAlear Mfg. Co.
McDonnell & Miller
Mercon Regulator Co.
Natural Gas Equipment
Northern Equip. Co.
Republic Flow Meters
Ruggles-Klingemann
Schade Valve Mfg. Co.
Simplex Valve & Meter
Watts Regulator Co.
Wilgus Mfg. Co.

CONTROLLERS, AUTOMATIC, Filter Rate
Cochrane Corp.
International Filter Co.
Mason-Neilan Reg. Co.
Taylor Inst. Cos.

CONTROLLERS, AUTOMATIC, Float
Allen-Bradley Co.
Autocall Co.
Automatic Control Co.
Automatic Temp. Control
Bailey Meter Co.
Cash Co.
Cochrane Corp.
Cutler-Hammer, Inc.
Davis Regulator Co.
Detroit Lubricator Co.
Furnas Electric Co.
Foster Engg. Co.

CONTROLLERS, Automatic, Float (Cont'd)
Foxboro Co.
Frick Co.
Hagan Corp.
Hanlon-Waters, Inc.
Kiely & Mueller
Mason-Neilan Regulator
McAlear Mfg. Co.
Mercon Regulator Co.
Penn Electric Switch
Powers Regulator Co.
Ruggles-Klingemann
Schade Valve Mfg. Co.
Simplex Valve & Meter
Spence Eng. Co., Inc.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Water Level Controls Co.

CONTROLLERS, AUTOMATIC, Flow
American Meter Co.
Arca Regulators
Askania Regulator
Bailey Meter Co.
Brown Inst. Co.
Bristol Co.
Cash Co.
Denver Fire Clay Co.
Electrimatic Corp.
Fischer & Porter
Foster Engg. Co.
Foxboro Co.
General Regulator Corp.
Hagan Corp.
Hanlon-Waters, Inc.
International Filter Co.
Leeds & Northrup Co.
Mason-Neilan Regulator
McAlear Mfg. Co.
Mercon Regulator Co.
Republic Flow Meters
Simplex Valve & Meter
Spence Eng. Co., Inc.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Victor Equipment Co.
Wilgus Mfg. Co.

CONTROLLERS, AUTOMATIC, Flow Proportioning
American Meter Co.
Arca Regulators, Inc.
Askania Regulator Co.
Autocall Co.
Automatic Temp. Control
Bailey Meter Co.
Barber-Coleman Co.
Bristol Co.
Brooke Eng. Co.
Brown Inst. Co.
Builders Iron Foundry
Cash Co.
Cochrane Corp.
Cutler-Hammer, Inc.
Electronic Prod. Co.
Fischer & Porter
Foxboro Co.
General Regulator Corp.
Hagan Corp.
Hanlon-Waters, Inc.
Hensley Co.
Illinois Engr. Co.
International Filter Co.
Lammert & Mann Co.
Mason-Neilan Regulator
McAlear Mfg. Co.
Mercon Regulator Co.
Republic Flow Meters Co.
Reynolds Gas Regulator
Simplex Valve & Meter
Spence Engr. Co., Inc.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Vergilio Co.
Victor Equipment Co.
Wheelco Inst. Co.

CONTROLLERS, AUTOMATIC, Fluid Proportioning (See Controllers, Automatic, Flow Proportioning)

CONTROLLERS, AUTOMATIC, Frequency (See Regulators)

CONTROLLERS, AUTOMATIC, Furnace
Am. Gas Furnace Co.
Arca Regulators, Inc.
Askania Regulator Co.
Automatic Elec. Mfg. Co.
Automatic Temp. Control
Bailey Meter Co.
Barber-Coleman Co.
Bristol Co.
Brooke Eng. Co.
Brown Inst. Co.
Cash Co.
Cook Electric Co.
Defender Automatic Reg.
Denver Fire Clay Co.
Detroit Lubricator Co.
Dickson Co.
Friez & Sons
Fulton Sylphon Co.
General Regulator Corp.
Gleason-Avery, Inc.
Hagan Corp.
Hays Corp.
Industrial Engr. Corp.
Johnston Mfg. Co.
Leeds & Northrup
Lindberg Eng. Co.
Marsh Corp.
Mason-Neilan Regulator
McCorkle Co.
National Airoil Burner
National Brass Co.
Natural Gas Equipment
Paragon Electric Co.
Partlow Corp.
Payne Furnace & Supply
Penn Electric Switch
Perfex Corp.
Pyrometer Inst. Co.
Republic Flow Meters
Ruggles-Klingemann
Spence Engineering Co.
Spencer Thermostat Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
United Cinephone Corp.
Wheelco Inst. Co.
White Mfg. Co.
White-Rodgers Electric
Wilgus Mfg. Co.

CONTROLLERS, AUTOMATIC, Gas Mixing (See Controllers, Automatic, Flow Proportioning)

CONTROLLERS, AUTOMATIC, Granular Material Level
Bin-Dicator Co.

CONTROLLERS, AUTOMATIC, Gravity
Arca Regulators, Inc.
Askania Regulator Co.
Bailey Meter Co.
Binckley, G. S.
Foxboro Co.
Mason-Neilan Regulator
Mine & Smelter Supply
Tagliabue Mfg. Co.
Taylor Inst. Cos.

CONTROLLERS, AUTOMATIC, Humidity
American Moistening Co.
Arca Regulators, Inc.
Atlas Valve Co.
Barber-Coleman Co.
Brabender Corp.

CONTROLLERS, Automatic Humidity (Continued)
Bristol Co.
Brown Inst. Co.
Consol. Ashcroft-Hancock
Cramer & Co., Inc.
Detroit Lubricator Co.
Dietert Co.
Electronic Prod. Co.
Fenwal, Inc.
Foxboro Co.
Friez & Sons
General Controls Co.
H-B Inst. Co., Inc.
Industrial Inst. Co.
Johnson Service Co.
Leeds & Northrup Co.
Mason-Neilan Regulator
McDonnell & Miller
Moeller Instrument Co.
Moisture Register Co.
Parks-Cramer Co.
Penn Electric Switch
Phila. Thermometer Co.
Powers Regulator Co.
Robertshaw Thermostat
Sarco Co., Inc.
Scientific Inst. Co.
Supreme Elec. Prods.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Thwing-Albert Inst. Co.
Trerice Co., H. O.
Vaughn-G. E. Witt Co.

CONTROLLERS, AUTOMATIC, Humidity and Temperature (See Controllers, Automatic, Humidity and Controllers, Automatic, Temperature)

CONTROLLERS, AUTOMATIC, Lighting
Betts & Betts
Cutler-Hammer, Inc.
Luxtrol Co., Inc.
Paragon Electric Co.
United Cinephone Corp.
Weston Elec. Inst. Corp.
Zenith Electric Co.

CONTROLLERS, AUTOMATIC, Liquid Level
Allen-Bradley Co.
American Meter Co.
Arca Regulators, Inc.
Askania Regulator Co.
Atlas Valve Co.
Autocall Co.
Bailey Meter Co.
Belfield Co.
Binckley, G. S.
Bin-Dicator Co.
Boylston Co.
Bristol Co.
Brown Inst. Co.
Builders Iron Foundry
Cash Co.
Cochrane Corp.
Consol. Ashcroft-Hancock
Cutler-Hammer, Inc.
Davis Reg. Co.
Electronic Prod. Co.
D'Este Co.
Elec. Indicator Co.
Fisher Governor Co.
Foster Engg. Co.
Foxboro Co.
Frick Co.
Furnas Electric Co.
General Controls Co.
General Regulator Corp.
Guardian Elec. Mfg. Co.
Hagan Corp.
Hanlon-Waters, Inc.
International Filter Co.
Johnson Service Co.
Kiely & Mueller
Klipfel Mfg. Co.
Lumenite Elec. Co.

CONTROLLERS, Automatic, Liquid Level (Cont'd)
Luxtrol Co., Inc.
Mason-Neilan Regulator
McAlear Mfg. Co.
McDonnell & Miller
Mercoid Corp.
Mercon Regulator Co.
National Airoil Burner
Natural Gas Equipment
Northern Equip. Co.
Paragon Electric Co.
Powers Regulators Co.
Precision Therm. & Inst.
Preferred Utilities Mfg.
Republic Flow Meters
Schade Valve Mfg. Co.
Simplex Valve & Meter
Spence Engineering Co.
Stets Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Uehling Instrument Co.
Water Levels Controls Co.
Watts Regulator Co.
Wheelco Inst. Co.
Wilgus Mfg. Co.

CONTROLLERS, AUTOMATIC, Load (See Regulators)

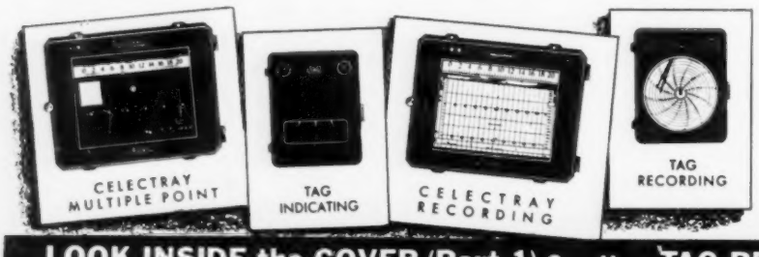
CONTROLLERS, AUTOMATIC, Moisture (See Controllers, Automatic, Humidity)

CONTROLLERS, AUTOMATIC, Phase (See Regulators)

CONTROLLERS, AUTOMATIC, Power Factor (See Regulators)

CONTROLLERS, AUTOMATIC, Pressure & Vacuum
Acme Regulator Co.
Allen-Bradley Co.
American Meter Co.
Arca Regulators, Inc.
Askania Regulator Co.
Arca Regulators, Inc.
Atlas Valve Co.
Autocall Co.
Automatic Control Co.
Automatic Temp. Control
Bailey Meter Co.
Baldwin-Southwark Corp.
Bastian-Blessing Co.
Belfield Co.
Boekel & Co.
Boylston Co.
Bristol Co.
Brooke Eng. Co.
Brown Inst. Co.
Builders Iron Foundry
Cash Co.
Connelly Iron Sponge Co.
Consol. Ashcroft-Hancock
Cutler-Hammer, Inc.
Davis Reg. Co.
D'Este Co.
Detroit Lubricator Co.
Dockson Co.
Eclipse Fuel Engg.
Emerson Apparatus Co.
Fisher Governor Co.
Ford Reg. Valve Co.
Foster Engg. Co.
Foxboro Co.
Friez & Sons
Fulton Sylphon Co.
Furnas Electric Co.
Gas Appl. Specialties
General Controls Co.
General Electric Co.
General Regulator Corp.
Gen. Sales & Prod.
Hanlon-Waters, Inc.
Hays Corp.

(Continued on Page 12)



TAG CONTROLLERS

Wherever the control of plant operations presents a production problem, TAG Automatic Controllers of either the electrical or air-operated types offer competent solution. These TAG Instruments have opened the way to better processing methods by more precise control of temperature, pressure and the time in which they act. Write for catalogs.

C. J. TAGLIABUE MFG. CO.
Park & Nostrand Aves., Brooklyn, N. Y.

LOOK INSIDE the COVER (Part 1) *See How* TAG RECORDERS *Save You Money* TAG

For addresses, see pages 56-64

COMPLETE INSTRUMENTATION

for INDUSTRIAL PROCESSES

CONTROLLERS for temperature, pressure, absolute pressure, rate of flow and liquid level. Air-operated potentiometer controllers. Exclusive features resulting in unexcelled performance.

RECORDERS of temperature, pressure, flow level, motion, absolute pressure.

INDICATORS of temperature, pressure, flow and level.

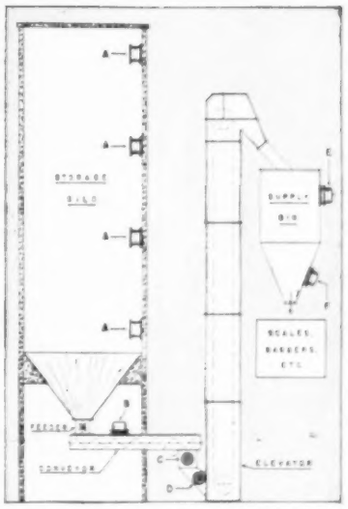
TRANSMISSION SYSTEMS, pneumatic type with exceptionally fast response. Electric signalling systems.

MASONEILAN

MASON-NEILAN REGULATOR CO.
1185 ADAMS ST., BOSTON, MASS., U. S. A.

BIN-LEVEL CONTROL

TYPICAL APPLICATIONS OF THE BIN-DICATOR



A. Bin-Dicators to indicate various levels of material in storage silo. (Can be mounted inside or out).

B. Bin-Dicator on screw conveyor cover—to indicate overfeed or underfeed—to automatically control (through solenoid valve) injection of compressed air into material—to provide uniform full feed of material.

C. Bin-Dicator at top of elevator boot to indicate overfeed, automatically shutting off conveyor in case of choking.

D. Bin-Dicator on lower part of elevator boot to indicate lack of feed.

E. & F. Bin-Dicators near top and bottom of bin—to indicate high and low level—to automatically shut off elevating machinery when bin gets full—to automatically shut off weighing or packing devices before bin becomes empty (thereby preventing errors due to lack of supply)—to automatically provide continuous supply of material in bin by starting and stopping elevator or conveyor as necessary.

NOTE: Variations in arrangement may of course be made, to provide practically any desired system of signalling or automatic control. Our engineering department will prepare detailed recommendations and wiring diagrams to meet YOUR requirements.

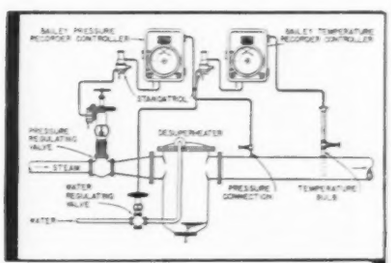
THE BIN-DICATOR COMPANY
14619 EAST JEFFERSON DETROIT, MICHIGAN

FLAME-OTROL
Combustion Safeguard
FOR ANY KIND OF FUEL

An actually fool-proof, instantaneous operating combustion safeguard that not only shuts off the fuel supply to the burner upon flame failure, but safeguards against interruption in its own electrical system, grounding of electrode and other dangerous conditions. It is non-mechanical—a radio impulse does the work.

Write for complete details.

Wheelco Instruments Co.
1929-33 S. HALSTED STREET • • • CHICAGO, ILLINOIS



DESUPERHEATING & PRESSURE REDUCING CONTROL

● Bailey Meter Control of desuperheating and pressure reducing incorporates standard Bailey Recorder-Controllers for both pressure and temperature, as well as a special Bailey Reducing Valve equipped with valve positioner and air cooled packing gland.

The control system is air-operated and is arranged to maintain the desired final steam temperature by controlling the quantity of water fed to a cartridge type desuperheater. This temperature is measured by a sensitive bare bulb temperature recorder-controller with the temperature bulb located at the
● outlet of the desuperheater.

BAILEY METER COMPANY
1041 IVANHOE ROAD - CLEVELAND, O.
Bailey Meter Company Ltd., Montreal, Canada

Bailey FEED WATER Control

● Bailey Meter Company offers three distinct feed water control systems. They are (1) the Thermo-hydraulic Feed Water Regulator which is suitable for the majority of small boilers operating at relatively low pressures. This regulator operates from water level alone and is provided with a fully balanced tight seating V-port regulating valve designed to give a straight line characteristic. It offers the advantages of low installation cost, removable valve parts and independence of valve location.

(2) The Single-Element air-operated feed water control system is recommended for installations on which smooth regulation of feed water flow is desired, and a wide regulating range cannot be used. This system is controlled by water level alone as measured by a Bailey Boiler Drum Water Level Recorder.

(3) Bailey Three-Element feed water control is recommended for high capacity low water storage boilers operating at high pressures or for boilers operating at medium pressures with violent load fluctuations. This system is based on actual measurement of water flow to the boiler, steam flow from the boiler and water level within the boiler, and is adjusted primarily to control the rate of water flow to the boiler so that it equals the rate of steam flow from the boiler.

For detailed information consult Sweet's Engineering Catalogs or request bulletin
● No. 183.

BAILEY METER COMPANY
1041 IVANHOE ROAD - CLEVELAND, O.
Bailey Meter Company Ltd., Montreal, Canada

CONTROLLERS, Automatic, Pressure (Cont'd)
Hoke, Inc.
Hydraulic Press Co.
Illinois Engg. Co.
Industrial Inst. Co.
Klipfel Mfg. Co.
Lammert & Mann Co.
Leeds & Northrup Co.
Leslie Co.
Marsh Corp.
Mason-Neilan Regulator
McAlear Mfg. Co.
McDonnell & Miller
Mercoid Corp.
Mercon Regulator Co.
Natural Gas Equip. Inc.
Northern Equip. Co.
Penn Electric Switch
Perfex Corp.
Powers Regulator Co.
Precision Therm. & Inst.
Ranco Inc.
Republic Flow Meters
Reynolds Gas Regulator
Robertshaw Thermostat
Ruggles-Klingemann
Schade Valve Mfg. Co.
Schwien Eng. Co.
Scientific Inst. Co.
Spence Engineering Co.
Spencer Thermostat Co.
Sterling Eng. Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Trerice Co., H. O.
Uehling Instrument Co.
Vapor Recovery Systems
Vaughn-G. E. Witt Co.
Victor Equipment Co.
Ward Leonard Elec. Co.
Water Level Controls Co.
Watts Regulator Co.
Wheelco Inst. Co.
White-Rodgers Electric
Wilgus Mfg. Co.

CONTROLLERS, AUTOMATIC, Pyrometric
Am. Gas Furnace Co.
Askania Regulator Co.
Automatic Temp. Control
Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Burling Inst. Co.
Dickson Co.
Electronic Lab.
Electronic Prod. Co.
Engelhard, Chas.
Ferner Co.
Foxboro Co.
General Elec. Co.
G-M Labs
Hagan Corp.
Hoskins Mfg. Co.
Ill. Testing Labs.
Industrial Instrument Co.

CONTROLLERS, Automatic Pyrometric (Cont'd)
J-B-T Instruments, Inc.
Leeds & Northrup Co.
Lewis Engg. Co.
Lindberg Eng. Co.
Mason-Neilan Regulator
Partlow Corp.
Pyrometer Instrument Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Thwing-Albert Instrument
Uehling Instrument Co.
Wheelco Inst. Co.

CONTROLLERS, AUTOMATIC, Radio Remote
Am. Automatic Electric
Guardian Elec. Mfg. Co.
RCA Manufacturing Co.
United Cinephone Corp.

CONTROLLERS, AUTOMATIC Rate-Volume (See Controllers, Automatic, Flow)

CONTROLLERS, AUTOMATIC, Refrigeration
Allen-Bradley Co.
Brown Inst. Co.
Cash Co.
Cutler-Hammer, Inc.
D'Este Co.
Detroit Lubricator Co.
Dickson Co.
Electrimatic Corp.
Frick Co.
Fulton Sylphon Co.
General Controls Co.
Illinois Engr. Co.
Lumenite Elec. Co.
Mason-Neilan Regulator
McAlear Mfg. Co.
Mercoid Corp.
Penn Electric Switch
Perfex Corp.
Phila. Thermometer Co.
Ranco, Inc.
Sarco Co., Inc.
Schade Valve Mfg. Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
White-Rodgers Electric

CONTROLLERS, AUTOMATIC, RKVA (See Regulators)

CONTROLLERS, AUTOMATIC Specific Gravity (See Controllers, Automatic, Gravity)

CONTROLLERS, AUTOMATIC, Speed (See Tachometric below)

CONTROLLERS, AUTOMATIC, Stoker (See Controllers, Automatic, Furnace)

CONTROLLERS, AUTOMATIC, Strain-Rate & Stress-Rate
Baldwin-Southwark Corp.

CONTROLLERS, AUTOMATIC, Synchronizing (See Regulators)

CONTROLLERS, AUTOMATIC, Tachometric
Askania Regulator Co.
Bailey Meter Co.
Barbour Stockwell Co.
Brown Inst. Co.
Cutler-Hammer, Inc.
Foxboro Co.
General Regulator Corp.
Mason-Neilan Regulator
Moisture Register Co.
Monitor Controller Co.
Republic Flow Meters

CONTROLLERS, AUTOMATIC, Temperature (See Pyrometric above or Thermometric below)

CONTROLLERS, AUTOMATIC, Temperature-Time (See Controllers, Automatic Thermometric; Controllers, Automatic, Thermostatic; Controllers, Automatic, Time)

CONTROLLERS, AUTOMATIC, Thermometric
Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Burling Inst. Co.
Consol. Ashcroft-Hancock
Dickson Co.
Edison Electrical Controls
Electrimatic Corp.
Electro-Medical Lab.
Emerson Apparatus Co.
Fish-Schurman Co.
Foxboro Co.
Friez & Sons
General Elec. Co.
General Regulator Corp.
Walter J. Halpern
H-B Inst. Co., Inc.
Ill. Testing Labs.
Lindberg Eng. Co.
Marsh Corp.
McAlear Mfg. Co.
Moeller Instrument Co.
Moisture Register Co.
Paragon Electric Co.
Parks-Cramer Co.
Partlow Corp.
Precision Therm. & Inst.
Scientific Inst. Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Trerice Co.
Wheelco Inst. Co.

CONTROLLERS, AUTOMATIC, Thermostatic
Accuracy Scientific Inst.
Allen-Bradley Co.
American Inst. Co.
Askania Regulator Co.
Atlas Valve Co.
Bailey Meter Co.
Barber-Coleman Co.
Boekel & Co.
Bristol Co.
Boiler Room Equip.
Brown Inst. Co.
Burling Inst. Co.
Bushnell & Nevins
Cook Electric Co.
Cramer & Co., Inc.
D'Este Co.
Detroit Lubricator Co.
Dickson Co.
Edison Electrical Controls
Ermstat Co.
Fenwal, Inc.
Fish-Schurman Co.
Friez & Sons
Foster Eng. Co.
Fulton Sylphon Co.
General Controls Co.
General Elec. Co.
Gleason-Avery, Inc.
H-B Inst. Co.
Halpern, Walter J.
Illinois Engr. Co.
Industrial Engr. Corp.
Johnson Service Co.
Kiely & Mueller
Klipfel Mfg. Co.
Leslie Co.
Marsh Corp.
McCorkle Co.
Mercoid Corp.
Moisture Register Co.
Partlow Corp.
Penn Electric Switch
Perfex Corp.
Phila. Thermometer Co.
Powers Regulator Co.
Precision Therm. & Inst.
Ranco Inc.
Rascher & Betzold
Robertshaw Thermostat
Ruggles-Klingemann
Sarco Co., Inc.
Spence Engineering Co.
Spencer Thermostat Co.
Sterling Eng. Co.
Struthers-Dunn
Tagliabue Mfg. Co.
Trane Co.
Vaughn-G. E. Witt Co.
Weston Elec. Inst. Corp.
White Mfg. Co.
White-Rodgers Elec. Co.

CONTROLLERS, AUTOMATIC, Time
Allen-Bradley Co.
Am. Gas Accumulator
Automatic Elec. Mfg. Co.
Automatic Temp. Control
Bailey Meter Co.
Betts & Betts
Bristol Co.
Consol. Ashcroft-Hancock
Cramer & Co., Inc.
Eagle Signal Corp.
Edison Electrical Prods.
Elec. Switch Corp.
Foxboro Co.
General Elec. Co.
Halpern, Walter J.
Hanlon-Waters, Inc.
Industrial Instrument Co.
Johnson Service Co.
Luxtrol Co., Inc.
Magnetic Gauge Co.
Mason-Neilan Regulator
Monitor Controller Co.
Paragon Electric Co.
Penn Electric Switch
Powers Regulator Co.
Stromberg Electric Co.
Struthers-Dunn
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Thomas Clock Co., Seth
United Cinephone Corp.
Warren Telechron Co.
Zenith Electric Co.

CONTROLLERS, AUTOMATIC, Vacuum (See Controllers, Automatic, Pressure)

CONTROLLERS, AUTOMATIC, Valve (See Valve-Operating Devices)

CONTROLLERS, AUTOMATIC, Viscosity
Brabender Corp.
Bailey Meter Co.
General Elec. Co.
Green, Arthur B.
Scientific Inst. Co.
United Cinephone Corp.

CONTROLLERS, AUTOMATIC, Voltage (See Regulators)

CONTROLLERS, AUTOMATIC, Volume (See Controllers, Automatic, Flow)

CONTROLLERS MANUAL (Non-automatic), Field
Cutler-Hammer, Inc.
General Elec. Co.
Monitor Controller Co.
National Elec. Controller
Schaefer Bros. Co.
Ward Leonard Elec. Co.
Westinghouse Elec. & Mfg.

CONTROLLERS, MANUAL (Non-automatic) Motor
Allen-Bradley Co.
Cutler-Hammer, Inc.
Elec. Controller & Mfg.
Furnas Electric Co.
General Elec. Co.
Monitor Controller Co.
National Elec. Controller
Schaefer Bros. Co.
Superior Electric Co.
Ward Leonard Elec. Co.
Westinghouse Elec. & Mfg.

CONTROLLERS, MANUAL (Non-automatic) Rheostatic
Allen-Bradley Co.
Allis-Chalmers Mfg. Co.
Beck Bros.
Cutler-Hammer, Inc.
Elec. Controller & Mfg.
General Elec. Co.
Monitor Controller Co.
National Elec. Controller
Ohmite Mfg. Co.
Rubicon Co.
Schaefer Bros. Co.
Ward Leonard Elec. Co.
Westinghouse Elec. & Mfg.

CONTROL SYSTEMS (See Controllers, Automatic)

COUNTERS, Alarm
Durant Mfg. Co.

COUNTERS, Colony
Fisher Scientific Co.
Spencer Lens Co.
Thomas Co., Arthur H.

COUNTERS, Cycle
Bristol Co.
General Elec. Co.
Industrial Inst. Co.
Moisture Register Co.
Paragon Electric Co.
Raytheon Mfg. Co.
Southwestern Electronics
Standard Elec. Time Co.
States Co.
United Cinephone Corp.
Ward Leonard Elec. Co.
Westinghouse Elec. & Mfg.

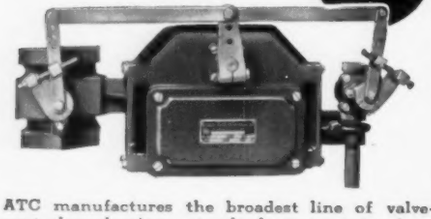
COUNTERS, Footage
Adde & Co.
Bristol Co.
Durant Mfg. Co.
Elec. Tachometer Corp.
McDonnell Odometer Co.

(Continued on page 14)

MOTOR-OPERATED CONTROLLERS

... by atc

For automatic control of Temperature, Level, Pressure, Flow



ATC manufactures the broadest line of valve-control mechanisms, standard types ranging from the simplest "off-on" control to fully balancing of the medium against the demand at any moment. Thousands now in use are demonstrating their accuracy, ruggedness and dependability. All models are easily installed from instructions accompanying shipments. Illustrated is the ATC RELATROL which provides compensating valve positions in direct relation to deviation from the control setting. To show sturdiness and simplicity two views are shown; the upper a front view with two valves, the lower a back view with heavy protective cover removed. Ask about ATC before specifying any valve-control devices.

SEND for BULLETIN G-10

which describes the various standard units

Representatives in Principal Cities

AUTOMATIC TEMPERATURE CONTROL CO.
25 E. Logan St. Philadelphia, Pa.

Taylor

FULSCOPE FLOW CONTROLLER

Write for complete information and catalogs.

Taylor Instrument Companies

ROCHESTER, N.Y. TORONTO, CANADA

Wheelco

POTENTIO-TROL

This revolutionary control instrument provides ultimate efficiency when applied to your most exacting temperature control problems. The combination of the highly sensitive Wheelco "Radio Principle" electronic control system and the time-proved potentiometric method of temperature measurement has established a degree of instantaneous control action heretofore unknown. Let us demonstrate how your production will benefit by this new control system.

Write for complete information.

Wheelco Instruments Co.
1929-33 S. HALSTED STREET · · · CHICAGO, ILLINOIS

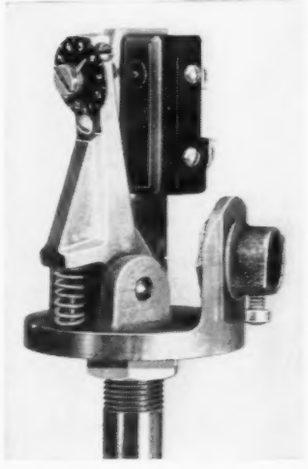
For addresses, see pages 56-64

Foxboro makes a comprehensive line of Air- and E'ectric-Operated Controllers for temperature, pressure, flow, liquid level and humidity. The control systems include every type from the simple Open-and Shut Control to the Foxboro Stabilog Control System —providing the ideal type of control for every job.

For information concerning the entire line of Foxboro Instruments and Controllers refer to "Sweet's Catalog", or write for a copy of Bulletin No. 199-2. The Foxboro Company, 46 Neponset Avenue, Foxboro, Mass., U.S.A. Branch offices in 25 Principal Cities.

Why Guess at . . .

CONTROL or LIMIT TEMPERATURES



HEAT CONTROL

Temperature Range Minus 100 to 600°F.
Other models to 1400°F.

Differentials ± ¼ deg. to ± 5 deg. F. Will give accurate control in ovens, tanks, incubators, water baths, dryers, chemical processes, and air ducts.

Send for Bulletin V-I.

BURLING INSTRUMENT CO.
239-241 Springfield Avenue
NEWARK, N. J.

Taylor

"Type-P" Expansion Stem
TEMPERATURE CONTROLLERS

Write for complete information and catalogs.

Taylor Instrument Companies
ROCHESTER, N.Y. TORONTO, CANADA

EDISON
THERMOSTATIC STEAM VALVE

PACKLESS TO 150 LBS. PRESSURE
FULLY BALANCED
2° Differential—5 Types

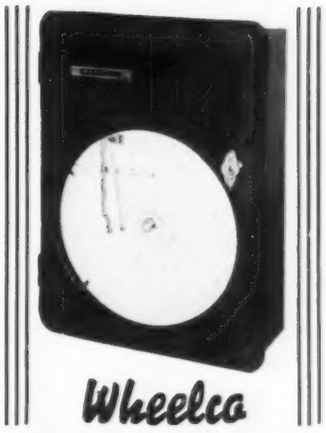
THOMAS A. EDISON, INC.
47 Lakeside Ave., West Orange, N. J.

Taylor

SELF-ACTING Temperature Controller

Write for complete information and catalogs.

Taylor Instrument Companies
ROCHESTER, N.Y. TORONTO, CANADA



Wheelco

RECORDING THERMO-TROL

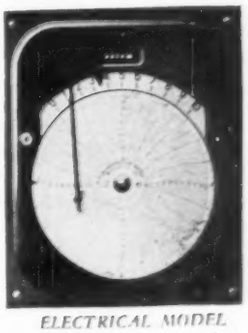
Now the famous Wheelco "Radio Principle" control system, that has been making control history for the past few years, is combined with a highly efficient thermometer recording unit. This control and recording combination especially designed for exacting requirements. The entire unit is enclosed in a dust and fume-proof case and chart is in clear view at all times.

Complete details on request.

Wheelco Instruments Co.
1929-33 S. HALSTED STREET · · · CHICAGO, ILLINOIS

ACCURATE CONTROL

Distinguished for extreme accuracy and high quality, Cochrane flow Meters are reliable guides for compiling records of consumption, intake, output and variation in the rate of flow of steam, gases, water and other liquids. The Electric Model utilizes the galvanometer null principle.



ELECTRICAL MODEL

MECHANICAL MODEL

The sensitive galvanometer detects the slightest change in rate of fluid flow, unaffected by friction or variations in voltage or frequency. Can be installed any distance from pipe line. The mechanical model develops an extremely high torque, is accurate in design, simple and rugged in construction.

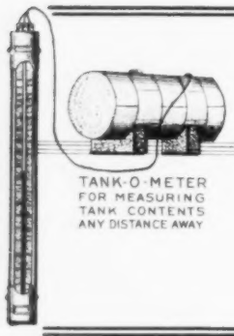
ORIFICE METERS AND TYPE E WEIR METERS

—have the same Cochrane accuracy and simplicity and are highly regarded by users for their particular applications.

Write for Publication Nos. 2092, 2094, 2096

COCHRANE CORPORATION
3120 N. 17th Street Philadelphia, Pa.

COCHRANE
FLOW METERS



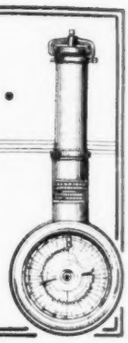
UEHLING INSTRUMENT CO.

Vacuum-Draft-CO_2

Absolute Pressure Recorders - Liquid Level Gauges

473 GETTY AVENUE

PATERSON, N.J.



COUNTERS, Footage (Cont'd)
Ohmer Register Co.
Saxl Inst. Co.
Southwestern Electronics
Talley-Meter Co.
United Cinephone Corp.
Veeder-Root, Inc.

COUNTERS, Geiger-Muller
Cambridge Instrument Co.
Geophys.cal Instrument
Vacutron, Inc.
Welch Scientific Co.

COUNTERS, Hour
Cramer & Co., Inc.
Elec. Tachometer Corp.
General Elec. Co.
Ohmer Register Co.
Paragon Electric Co.
Southwestern Electronics
United Cinephone Corp.
Warren Telechron Co.
Westinghouse Elec & Mfg.
Weston Elec. Inst. Corp.

COUNTERS, Lumber
Adde & Co.
Durant Mfg. Co.
Keuffel & Esser Co.
McDonnell Odometer Co.
Moisture Register Co.
Tally-Meter Co

COUNTERS, Photoelectric
Ess Instrument Co.
Lumenite Electric Co.
Paver-Sills Co.
Photobell Corp.
Production Instrument
Vacutron, Inc.
United Cinephone Corp.
Weston E'ectrical Inst.

COUNTERS, Production
Adde & Co.
Bristol Co.
Cramer & Co., Inc.
Durant Mfg. Co.
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Ohmer Register Co.
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United Cinephone Corp.
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Cummings Machine Wks.
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Hart Mfg. Co., R. E.
International Register Co.
Luxtrol Co., Inc.
McDonnell Odometer Co.
Moisture Register Co.
Photobell Corp.
Ohmer Register Co.
Production Inst. Co.
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Bruesh Development Co.
General Radio Co.
Premier Crystal Labs.
RCA Manufacturing Co.
Valpey Crystals
Zeiss, Inc., Carl

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Bliley Electric Co.
Fuess, Inc.
General Radio Co.
Master Optical Co.
Premier Crystal Labs.
RCA Manufacturing Co.
Valpey Crystals

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Brush Development Co.

CRYSTALS, Tourmaline
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General Elec. Co.
Monitor Controller Co.

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CURRENT REGULATORS (See Regulators, Current)

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DECIBEL METERS (See Sound Level Meters)

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DEMAND, Recorders (See Meters, Demand)

DEMAND — LIMITING METERS (See Meters, Demand Limiting)

DEMAND METERS (See Meters, Demand)

DEMAND TOTALIZING RELAYS & DEVICES (See Relays, Demand Totalizing)

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Tagliabue Mfg. Co.

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Gaertner Scientific Corp.
Gurley, W. & L. E.
Zeiss, Inc., Carl

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Federal Prod. Corp.
Gen. Engg. & Model Wks.
Starrett Co.

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DEPTH, Recorders, Liquid (See Gages, Liquid Level, Indicating)

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Sperry Products, Inc.

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DETECTORS, Carbon Monoxide Mine Safety Appliances

DETECTORS, Hydrogen Cyanide Mine Safety Appliances

DETECTORS, Hydrogen Sulphide Mine Safety Appliances

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Geophysical Inst. Co.
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McFarlin Co.
RCA Manufacturing Co.
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Mine Safety Appliances

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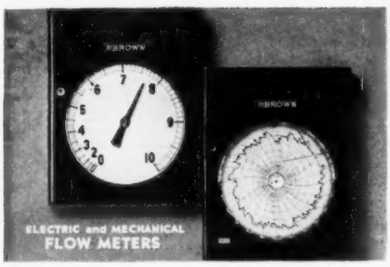


For Controlling, Recording, Totalizing and Indicating the Flow of Fluids such as Steam, Water, Gas, Oil, etc.

Brown Flow Meters are available in two types, the Electric type and Mechanical type.

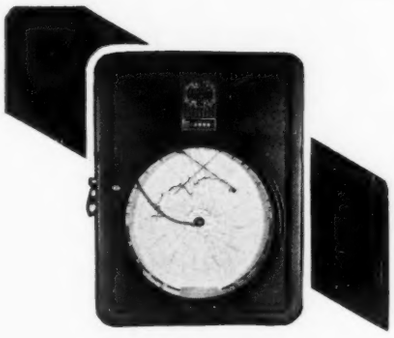
ELECTRIC TYPE: Complete equipment consists of three units, the orifice plate, manometer and instrument. Instrument can be located at a remote point from the orifice and manometer (point of flow measurement).

Because of this flexibility, it is particularly adaptable for applications where instruments are to be remotely located for control purposes.

MECHANICAL TYPE: Complete equipment consists of two units, the orifice plate and the instrument. The meter body is integral with the instrument. Readings are transmitted mechanically from meter body to instrument.

Write for Catalog 2006. THE BROWN INSTRUMENT COMPANY, *a division of Minneapolis-Honeywell Regulator Co.*, 4482 Wayne Avenue, Philadelphia, Pa.

BROWN FLOW METERS
AND
MINNEAPOLIS-HONEYWELL CONTROL SYSTEMS
To Measure and Control is to Economize



BAILEY
Fluid Meters
For STEAM · LIQUIDS · GASES

● Bailey Fluid Meters are designed to indicate, record and integrate the flow of steam, liquids, or gases under practically any pressure or temperature condition.

A great variety of indicating, recording and integrating combinations are available for use with four distinct types of flow mechanisms.

This large variety of possible combinations enables the flow meter engineer to specify equipment which is pre-eminently suited to any flow measuring application.

When it is desired to place indicators, recorders and integrators at a considerable distance from the primary element, Bailey Synchro-Meters are available to provide electric transmission.

For detailed information consult Sweet's Engineering Catalogs or request a copy of bulletin No. 301.

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Machlett & Son
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Brabender Corp.
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Ferner Co.
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Hayes Scientific Apps.
Holz, Herman A.
Olsen Testing Machine
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Triangle Package Mach.
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Bowser & Co.
FILLING MACHINES, Can
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FILLING MACHINES, Carton
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Kollmorgen Optical Co.
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Veritas Firing System
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Clark & Sons
Fecker, J. W.
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Fish-Schurman Co.
Fuess, Inc.
Gaertner Scientific Corp.
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Master Optical Co.
Mico Instrument Co.
Perkin, Elmer & Moffitt
Scherr Co., Inc., George
Van Keuren Co.
Woermann-Schuchhardt
Zeiss, Inc., Carl
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Thermal Syndicate Ltd.

"FLOW"

(Flowmeters measure primarily RATE of flow. For positive or "quantity" fluid meters, see the numerous classes under "Meters")

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Commercial Engg. Labs.
Fischer & Porter
Friez & Sons
National Meter Co.
FLOWMETERS, AREA Cylinder & Piston Type
American Inst. Co.
Bowser & Co.
Brown Inst. Co.
Fischer & Porter
National Meter Co.
New Jersey Meter Co.
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D'Este Co.
Fischer & Porter
Fish-Schurman Corp.
Hoke, Inc.
Schutte & Koerting Co.
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Binckley, George Sidney
Brown Inst. Co.
Cochrane Corp.
Fischer & Porter
Mason-Neilan Regulator
Republic Flow Meters
Taylor Inst. Cos.
FLOWMETERS, BLAST
Bacharach Industrial Inst.
Bailey Meter Co.
Brown Inst. Co.
Clark Blast Meter
Cochrane Corp.
Foxboro Co.
Meriam Co.
Tagliabue Mfg. Co.
FLOWMETERS, GAS
Ace Glass, Inc.
American Gas Furnace
American Inst. Co.
American Meter Co.
Bacharach Industrial Inst.
Bailey Meter Co.
Binckley, G. S.
Bowser & Co.
Bristol Co.
Brown Inst. Co.
Builders Iron Fdry.
Clark Blast Meter
Cochrane Corp.
Commercial Engg. Labs.
D'Este Co.
Detroit Air Meter Co.
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Elec. Indicator Corp.
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Gas Appliance Specialties
Henszey Co.
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Ill. Testing Labs.
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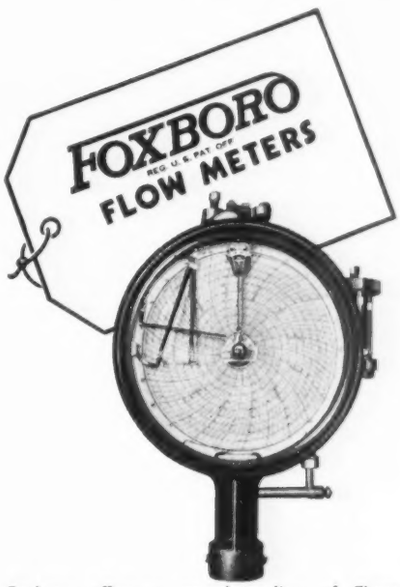
(Continued on next page)



Foxboro offers a complete line of Flow Meters for measuring steam, gas, air, oil, water, acids and other fluids. These meters are of the orifice type—simple in design, powerful, with a straight-line motion that assures permanent calibration and long life. They can be furnished with direct-reading integrator to give total flow. Recorders may also be equipped with pressure, temperature and integrator pens.

For complete information write for Bulletin 200-3 and Bulletin 692. The Foxboro Company, 46 Neponset Avenue, Foxboro, Mass., U.S.A. Branch offices in 25 Principal Cities.

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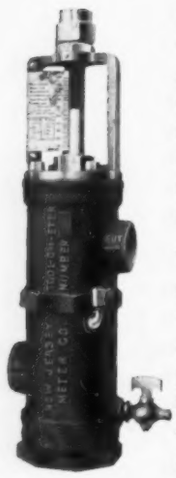
Taylor
DIAL-TYPE FLOW INDICATORS
Write for complete information and catalogs.
Taylor Instrument Companies
ROCHESTER, N.Y. TORONTO, CANADA

For addresses, see pages 56-64

New Jersey Air Meters

TOOL-OM-ETER and DRILL-OM-ETER



Measure the flow of Compressed Air to any process or tool. Guide the maintenance of pneumatic equipment in effective working condition.

These meters are of the constant head, variable orifice type, simple, reliable, portable, only one moving part. Used on air and other gases at 1-300 lb.

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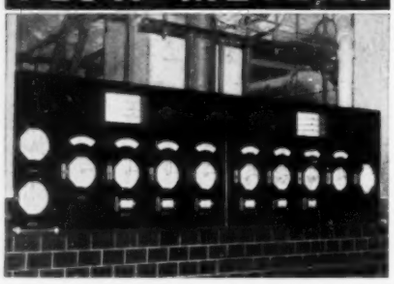
PLAINFIELD, N. J.

FLOW METERS



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WORKING PRESSURES
Republic meters are available for all working pressures up to 5000 lb. per sq. in.

RANGE EASILY CHANGED
The range of a Republic meter can be easily and quickly changed by merely changing the range tube.

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The Republic indicator, recorder and integrator operate independently of each other and can be supplied separately or in combination. They are remote reading.

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The indicator scale and the recorder chart all have uniform graduations and are direct reading. The integrator has a large cyclometer type dial.

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Morey & Jones, Ltd.
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New Jersey Meter Co.
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Scientific Inst. Co Calif.
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Bailey Meter Co.
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Bristol Co.
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Cochrane Corp.
Commercial Engg. Labs.
Elmer & Amend
Fischer & Porter
Foxboro Co.
Hoke, Inc.
Jensen Inst. Co.
Lambert Meter Co., Inc.
Leeds & Northrup Co.
Leupold. Volpel & Co.
Mason-Neilan Regulator
Meriam Co.
Morey & Jones, Ltd.
Permutit Co.
Pgh. Equitable Meter
Republic Flow Meters
Ruska & Co., Inc.
Scientific Glass Apparatus
Scientific Inst. Co.
Simplex Valve & Meter
Tagliabue Mfg. Co.
Taylor Inst. Cos.

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Askania Regulator Co.
Bacharach Industrial Inst.
Bailey Meter Co.
Binckley, G. S.
Bristol Co.
Brown Inst. Co.
Builders Iron Foundry
Cambridge Inst. Co.
Central Scientific Co.
Cochrane Corp.
Defender Automatic Reg.
Detroit Air Meter Co.
Foxboro Co.
Friez & Sons
Fuess, Inc.
Kollsman Inst. Co.
Meriam Co.
Morey & Jones, Ltd.
Pitometer Log Corp.
Precision Therm. & Inst.
Refinery Supply Co.
Republic Flow Meters
Simplex Valve & Meter
Taylor Inst. Cos.

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American Meter Co.
Bailey Meter Co.
Binckley, G. S.
Bristol Co.
Brown Inst. Co.
Builders Iron Fdry.
Cochrane Corp.
Foxboro Co.
Jensen Inst. Co.
Leeds & Northrup Co.
Mason-Neilan Regulator
Meriam Co.
Morey & Jones, Ltd.
Republic Flow Meters
Simplex Valve & Meter
Tagliabue Mfg. Co.
Taylor Inst. Cos.

FLOWMETERS, Vane
Autocall Co.
Detroit Air Meter Co.
Friez & Sons
Ill. Testing Labs.
Mason-Neilan Regulator
Simplex Valve & Meter

FLOWMETERS, Venturi
Bailey Meter Co.
Binckley, G. S.
Bristol Co.
Brown Inst. Co.
Builders Iron Foundry
Cochrane Corp.
Foxboro Co.
International Filter Co.
Jensen Inst. Co.
Leupold. Volpel & Co.
Mason-Neilan Regulator
Morey & Jones, Ltd.
Republic Flow Meters
Simplex Valve & Meter
Taylor Inst. Cos.

FLOWMETERS, Weir
Bailey Meter Co.
Binckley, G. S.
Bristol Co
Brown Inst. Co.
Builders Iron Fdry.
Cochrane Corp.
Elec. Indicator Corp.
Foxboro Co.
Gurley, W. & L. E.
Leupold. Volpel & Co.
Mason-Neilan Regulator
Morey & Jones, Ltd.
Simplex Valve & Meter
Taylor Inst. Cos.

FLUE GAS ANALYZERS (See Gas Analyzers, Flue Gas)

FLUID METER, GAS (See Gas Meters)

FLUID METERS, LIQUID (See Meters, Liquid)

FLUID METERS, QUANTITY (See Gas Meters; Meters, Current; Meters, Liquid)

FLUORESCENT CHEMICALS
Black-Ray Lighting Co.
Central Scientific Co.
Pfaltz & Bauer, Inc.
Patterson Screen Co.

FLUORESCENT MERCURY VAPOR TUBES EMITTING WHITE LIGHT (See Light Sources)

FLUOROSCOPES
General Electric X-Ray
Patterson Screen Co.
Westinghouse X-Ray Co.

FLUXMETERS
Annis Co.
Cambridge Inst. Co.
Central Scientific Co.
General Elec. Co.
Leeds & Northrup Co.
Rawson Electrical Inst.
Rubicon Co.
Sensitive Research Inst.

FOLDING ENDURANCE TESTERS (PAPER) (See Testers, Folding Endurance)

FOOT BLOCKS
Ford Motor Co.

FOOT CANDLE METERS
Central Scientific Co.
De Jur-Amsco Corp.
General Elec. Co.
G-M Labs.
Intercontinental Market.
Loewenberg, F.
Luxtrol Co., Inc.
Pfaltz & Bauer, Inc.
United Cinephone Corp.
Weston Elec. Inst. Corp.

FOREWARN DETECTOR, for locating hidden weapons (See Detectors, Metal)

FORKS, Synchronization
Elec. Tachometer Corp.
Gaertner Scientific Corp.
Riverbank Laboratories

FORKS, Tuning
Clay-Adams Co.

FORKS, Tuning, Electrically Driven
Cambridge Inst. Co.
Central Scientific Co.
Chicago Apparatus Co.
Elec. Tachometer Corp.
Engineering Labs., Inc.
Gaertner Scientific Corp.
General Radio Co.
Hathaway Inst. Co.
Riverbank Laboratories
Welch Mfg. Co.

FORKS, Vacuum Driven
Cambridge Inst. Co.
Gaertner Scientific Corp.
Riverbank Laboratories

FRACTIONAL HORSEPOWER MOTORS (See Motors, Fractional Horsepower)

FREENESS TESTERS (See Testers, Freeness)

FREQUENCY METERS, Controlling
General Elec. Co.
Leeds & Northrup Co.

FREQUENCY Meters, Electronic
De Jur-Amsco Corp.
General Radio Co.
RCA Manufacturing Co.

FREQUENCY METERS, Indicating
General Elec. Co.
General Radio Co.
Hickok Elec. Inst. Co.

FREQUENCY METERS, Indicating (Cont'd)
Leeds & Northrup Co.
RCA Manufacturing Co.
Roller-Smith Co.
Sensitive Research Inst.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

FREQUENCY METERS, Recording
Bristol Co.
Esterline-Angus Co.
General Elec. Co.
Leeds & Northrup Co.
Roller-Smith Co.
Warren Telechron Co.
Westinghouse Elec & Mfg.

FREQUENCY METERS, Standards
Bliley Electric Co.
Ferris Inst. Corp.
RCA Manufacturing Co.

FREQUENCY METERS, Vibrating Reeds
Biddle Co., Jas. G.

FRITTED GLASS FILTERS & APPARATUS
Central Scientific Co.
Fish-Schurman Co.
Pfaltz & Bauer, Inc.

FUEL ANALYSIS APPARATUS
Central Scientific Co.
Elmer & Amend
Machlett & Son
Parr Instrument Co.
Precision Scientific Co.
Sargent & Co.
Tagliabue Mfg. Co.

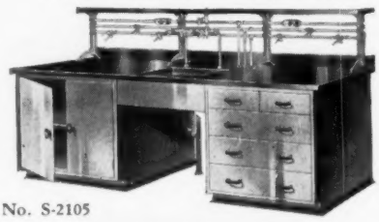
FUEL FLOW INDICATORS
Askania Regulator Co.
Autocall Co
Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Commerical Eng. Labs.
Eclipse Aviation
Fischer & Porter
Foxboro Co.
Hagan Corp.
Mason-Neilan Regulator
National Airoil Burner
Taylor Inst. Cos.
Victor Equipment Co.

FURNACE CONTROL SYSTEMS (See Controllers, Automatic)

FURNITURE, LABORATORY
Hamilton Mfg. Co.
Kewaunee Mfg. Co.
Kimball Co., W. W.
Laboratory Const. Co.

An Ideal Wall Table

. . . for Small Control and Private Research Laboratories



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For addresses, see pages 56-64

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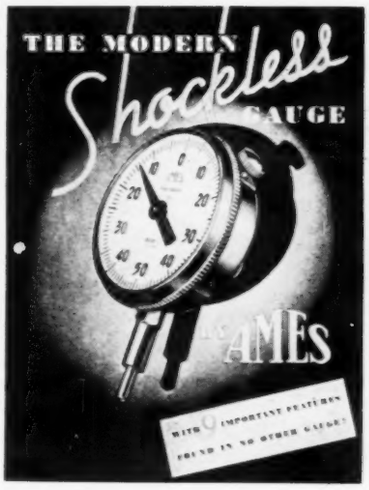

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Moline Furniture Works
Precise Instrument Co.
Sheldon & Co.
Sjostrom Co.
Southern Desk Co.
Welch Mfg. Co.

FUSES, INSTRUMENT
Littelfuse Labs.
Meter Devices Co.

GAGE BLOCKS
Ford Motor Co.
Pratt & Whitney
Van Keuren Co.

GAGE GLASS ILLUMINATORS
Wright-Austin Co.

GAGE TESTERS, Deadweight
American Inst. Co.
Amthor Testing Inst. Co.
Ashton Valve Co.
Consol. Ashcroft-Hancock
Crosby Steam Gage Co.
Holz, Herman A
Olsen Testing Machine
Refinery Supply Co.
Star Brass Mfg. Co.

GAGE TESTERS, Fluid-scale
Crosby Steam Gage Co.

GAGE TESTERS, Liquid-column
Consol. Ashcroft-Hancock

GAGES (See also object of Measurement and control)

GAGES, Absolute Pressure
Bailey Meter Co.
Binckley, G. S.
Bristol Co.
Brown Inst. Co.
Consol. Ashcroft-Hancock
Emery Co.
Foxboro Co.
Kollsman Inst. Co.
Mason-Neilan Regulator
Moeller Instrument Co.
Precision Therm. & Inst.
Scientific Inst. Co.
Taglabue Mfg. Co.
Taylor Inst. Cos.
Uehling Instrument Co.
United States Gauge Co.
Victor Equipment Co.

GAGES, Air
Ashton Valve Co.
Bailey Meter Co.
Bastian-Blessing Co.
Bristol Co.
Consol. Ashcroft-Hancock
Detroit Air Meter Co.
Foxboro Co.
Friez & Sons
Lambert Meter Co., Inc.
Marsh Corp.
Mason-Neilan Regulator
Rochester Mfg. Co.
Star Brass Mfg.
Taglabue Mfg. Co.
Trerice Co.
Uehling Inst. Co.
U. S. Gage Co.
Victor Equipment Co.

GAGES, Alarm
Ashton Valve Co.
Bailey Meter Co.
Bristol Co.
Consol. Ashcroft-Hancock
Crosby Steam Gage
Foxboro Co.
Marsh Corp.
Mason-Neilan Regulator
Precision Therm. & Inst.
Star Brass Mfg.
Trerice Co.
U. S. Gage Co.

GAGES, Amplifying
Coats Mach. Tool Co.
Comtor Co.
Federal Prod. Corp.
North Side Tool Co.
Precision Gage & Tool
Saxl Instr. Co.
United Cinephone Corp.

GAGES, Automatic Sorting
Instrument Specialties Co.

GAGES, Bore
Brown & Sharpe
Comtor Co.
Federal Prod. Corp.
Pratt & Whitney
Scherr Co.
Sheffield Gage

GAGES, Bourdon
Ashton Valve Co.
Bailey Meter Co.
Baldwin-Southwark Corp.
Bastian-Blessing Co.
Bellfield Co.
Bristol Co.
Brown Inst. Co.
Consol. Ashcroft Hancock
Crosby Steam Gage
Dickson Co.
Emery Co.
Foxboro Co.
Hays Corp.
Helse Bourdon Tube Co.
Hoke, Inc.
Improved Gauge Mfg.
Marsh Corp.
Mason-Neilan Regulator
Merroid Corp.
Republic Flow Meters
Star Brass Mfg. Co.
Taglabue Mfg. Co.
Taylor Inst. Cos.
Trerice Co.
United States Gauge Co.

GAGES, Caliper (Dial)
Brown & Sharpe
Federal Prod. Corp.
Glogau & Co.
Starrett Co.

GAGES, Center
Lufkin Rule Co.
Millers Falls Co.
Starrett Co.
Union Tool Co.

GAGES, Comparator
Ames Co., B. C.
Coats Mach. Tool Co.
Comtor Co.
Federal Prod. Corp.
Gaertner Scientific Corp.
General Engg. & Model
Instrument Specialties Co.
Jones & Lamson Machine
North Side Tool Co.
Pratt & Whitney
Precision Gage & Tool
Saxl Inst. Co.
Scherr Co.
Sheffield Gage
United Cinephone Corp.

GAGES, Compression
Allen Elec. & Equip.
Bacharach Indus. Inst.
G. M. Co. Mfg.
Riehle Div.
Saxl Inst. Co.
Toledo Scale Co.
United States Gauge Co.

GAGES, Cylinder
Ames Co., B. C.
Coats Mach. Tool
Comtor Co.
Federal Prod. Corp.
Lufkin Rule Co.
Pratt & Whitney
Starrett Co.
United Cinephone
Victor Equipment

GAGES, Depth, Linear
Ames Co., B. C.
Brown & Sharpe
Glogau & Co.
Instrument Specialties
Lufkin Rule Co.
Pratt & Whitney
Starrett Co.
Union Tool Co.

GAGES, Depth, Navigational
Geophysical Inst. Co.

GAGES, Dial, Machinists'
Ames Co., B. C.
Brown & Sharpe
Chicago Dial Ind.
Federal Prod. Corp.
Ferner Co.
Genales Andrew
General Engg & Model
Randall, Frank E.
Starrett Co.
Waltham Dial Gage

GAGES, Differential Pressure
American Meter Co.
Bacharach Industrial Inst.
Bailey Meter Co.
Binckley, G. S.
Boiler Room Equip.
Bristol Co.
Brown Inst. Co.
Consol. Ashcroft Hancock
Crew Equip. Co.
Crosby Steam Gage
Defender Automatic Reg.
Detroit Air Meter Co.
Dwyer Mfg. Co.
Ellison Draft Gage Co.
Foxboro Co.
Friez & Sons
Fuess, Inc.
Gas Appliance Specialties
Hays Corp.
Jensen Inst. Co.
Lambert Meter Co.
Mason-Neilan Regulator
Meriam Co.
Moeller Instrument
Morey & Jones, Ltd.
Pitometer Log Corp.
Precision Therm. & Inst.
Preferred Utilities Mfg.
Republic Flow Meters
Scientific Glass Apparatus
Scientific Inst. Co.
Simplex Valve & Meter
Taglabue Mfg. Co.
Taylor Inst. Co.
Uehling Instrument Co.
U. S. Gage Co.

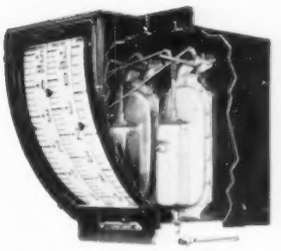
GAGES, Draft (See Gages, Differential Pressure)

GAGES, Drill Grinding
Lufkin Rule Co.
Morse Twist Drill
Starrett Co.

GAGES, Feeler
Improved Gauge Mfg.
Lufkin Rule Co.
Millers Falls Co.
Starrett Co.
Union Tool Co.
Van Keuren Co.

GAGES, Gas
Abercrombie Pump Co.
American Meter Co.
Bailey Meter Co.
Bastian-Blessing
Bristol Co.
Connelly Iron Sponge
Detroit Air Meter
Dickson Co.
Foxboro Co.
Gas Appliance Specialties
Lambert Meter Co.
Linde Air Products
Mason-Neilan Regulator

(Continued on next page)



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For addresses, see pages 56-64

GAGES, Gas (Cont'd)
Rochester Mfg. Co.
Specialty Glass Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Victor Equipment

GAGES, Grinding
Ames Co., B. C.
Brown & Sharpe
Comtor Co.
Federal Prod. Corp.
Lufkin Rule Co.

GAGES, Height
Brown & Sharpe
Ford Motor Co.
General Engg. & Model
Lufkin Rule Co.
Scherr Co.
Starrett Co.

GAGES, Hook
Gurley, W. & L. E.
Scientific Inst. (Calif.)
White Co., Inc.

GAGES, Hydrostatic (See Gages, Liquid Level, Indicating)

GAGES, Internal Dial
Coats Mach. Tool
Comtor Co.
Federal Prod. Corp.
Gen. Engg. & Model Wks.
Scherr Co.

GAGES, Limit
Ford Motor Co.
General Elec. Co.
Gen. Engg. & Model Wks.
Greenfield Tap & Die
Meldrum-Gabrielson
Pratt & Whitney
Sheffield Gage
United Cinephone
Van Keuren Co.

GAGES, Liquid Level, Indicating
American Meter Co.
Ashton Valve Co.
Autocall Co.
Bacharach Industrial Inst.
Bailey Meter Co.
Bastian-Blessing
Binckley, G. S.
Bin-Dicator Co.
Boston Auto Gage
Bowser & Co.
Bristol Co.
Brown Inst. Co.
Builders Iron Foundry
Burt Scientific Labs.
Cochrane Corp.
Consol. Ashcroft Hancock
Crosby Steam Gage

GAGES, Liquid Level, Indicating (Cont'd)
Davis Reg. Co.
Defender Automatic Reg.
Dickson Co.
Elec. Indicator Corp.
Elec. Tachometer Corp.
Fisher Governor Co.
Foxboro Co.
Frick Co.
General Controls Co.
General Elec. Co.
Gurley, W. & L. E.
Hanlon-Waters, Inc.
International Filter Co.
Jensen Inst. Co.
Jerguson Gage Co.
Johnston & Jennings
Kellogg Switchboard
King-Seeley
Klingerit, Inc.
Leeds & Northrup Co.
Leupold, Volpel
Liquidometer Co.
Lumenite Elec. Co.
Luxtrol Co., Inc.
Marsh Corp.
Mason-Neilan Regulator
McAlear Mfg. Co.
McNeill Engr. Equip.
Meriam Co., The
Morey & Jones, Ltd.
Nathan Mfg. Co.
Natural Gas Equipment
Paragon Electric
Penberthy Injector Co.
Petrometer Corp.
Pioneer Instrument Co.
Pneumercator Co., Inc.
Precision Therm. & Inst.
Preferred Utilities Mfg.
Reliance Gauge Column
Republic Flow Meters
Rochester Mfg. Co.
Schutte & Koerting Co.
Simplex Valve & Meter
Star Brass Mfg.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Uehling Instrument Co.
Vapor Recovery Systems
Wallace & Tiernan
Westinghouse Elec. & Mfg.
Wheelco Inst. Co.
Williams Gauge Co.
Wright-Austin Co.
Yarnell-Waring Co.

GAGES, Liquid Level, Recording (See Gages, Liquid Level, Indicating)

GAGES, Loss of Head
Bailey Meter Co.
Binckley, G. S.
Bristol Co.

GAGES, Loss of Head (Cont'd)
Builders Iron Foundry
Foxboro Co.
International Filter Co.
Jensen Inst. Co.
Morey & Jones, Ltd.
Taylor Inst. Cos.

GAGES, Mercury
Bacharach Industrial Inst.
Bailey Meter Co.
Builders Iron Foundry
Central Scientific
Connelly Iron Sponge
Consol. Ashcroft Hancock
Defender Automatic Reg.
Dubrovin, John
Dwyer Mfg. Co.
Eimer & Amend
Gas Appliance Specialties
General Physical Lab.
Heise Bourdon Tube Co.
Jensen Inst. Co.
Machlett & Son
Mason-Neilan Regulator
Meriam Co.
Moeller Instrument
Morey & Jones
Precision Therm. & Inst.
Refinery Supply Co.
Scientific Glass Apparatus
Simplex Valve & Meter
Specialty Glass Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Trerice Co.
Uehling Instrument Co.

GAGES, Micrometer
Ames Co., B. C.
Brown & Sharpe
Central Scientific Co.
Coats Mach. Tool Co.
Gaertner Scientific Corp.
Haines Gauge Co.
Instrument Specialties Co.
Lufkin Rule Co.
Precision Therm. & Inst.
Scherr Co.
Van Keuren Co.
Millers Falls Co.
Zeiss, Inc., Carl

GAGES, Oil
Abercrombie Pump Co.
Bailey Meter Co.
Boston Auto Gage
Heise Bourdon Tube Co.
Mason-Neilan Regulator
Nathan Mfg. Co.
Penberthy Injector Co.
Petrometer Corp.
Rochester Mfg. Co.
Uehling Inst. Co.
U. S. Gauge Co.

GAGES, Optical
Bausch & Lomb Optical
Chicago Dial Ind. Co.
Clark & Sons
Fecker, J. W.
Gaertner Scientific Corp.
Jones & Lamson Machine
Scherr Co.
United Cinephone Corp.
Zeiss, Inc., Carl

GAGES, Paint Film
General Elec. Co.
Hathaway Inst. Co.
Instrument Specialties Co.
Munsell Color Co.
Saxl Inst. Co.

GAGES, Paper Thickness (See Gages, Thickness)

GAGES, Piston Ring
Holz, Herman
Littelfuse Inc.
Wilkening Mfg. Co.

GAGES, Pitch Diameter
Brown & Sharpe
Federal Prod. Corp.
Greenfield Tap & Die
Lufkin Rule Co.
Pratt & Whitney
Scherr Co., Inc.
Union Tool Co.
Van Keuren Co.
West & Dodge Thr. Gage

GAGES, Plug
Brown & Sharpe
Ford Motor Co.
Greenfield Tap & Die
Morse Twist Drill
Pratt & Whitney
Precision Gage & Tool
Sheffield Gage
West & Dodge Thr. Gage

GAGES, Pneumatic Tank
Bacharach Industrial
Mason-Neilan Regulator
Pneumercator Co.
Rochester Mfg. Co.
Uehling Inst. Co.

GAGES, Precision Measuring
Ames Co., B. C.
Brown & Sharpe
Comtor Co.
Federal Prod. Corp.
Ferner Co.
Ford Motor Co.
Gaertner Scientific Corp.
Instrument Specialties Co.
Lufkin Rule Co.
Pratt & Whitney
Rieker Instrument Co.
Scherr Co., Inc.
Sheffield Gage
Starrett Co.

GAGES, Precision Measuring (Cont'd)
Thwing-Albert Inst. Co.
Van Keuren Co.
Carl Zeiss, Inc.

GAGES, Pressure, Indicating
Abercrombie Pump Co.
Allen Elec. & Equip.
American Meter Co.
Ashton Valve Co.
Bacharach Industrial Inst.
Bailey Meter Co.
Baird Associates
Baldwin-Southwark Corp.
Bastian-Blessing
Belfield Co.
Boekel & Co.
Bristol Co.
Brown Inst. Co.
Brush Development Co.
Central Scientific Co.
Clark Blast Meter
Commercial Eng. Labs.
Consol. Ashcroft Hancock
Continental Elec. Co.
Crew Equip. Co.
Crosby Steam Gage
Defender Automatic Reg.
Dickson Co.
Dubrovin, John
Eimer & Amend
Emery Co.
Esterline-Angus Co.
Fisher Scientific Co.
Foxboro Co.
Friez & Sons
Gas Appliance Specialties
General Elec. Co.
General Physical Lab.
Green, Henry J.
Halpern, Walter J.
Hays Corp.
Heise Bourdon Tube Co.
Hoke, Inc.
Industrial Instrument Co.
Jerguson Gage Co.
King-Seeley Corp.
Kollsman Inst. Co.
Kurman Electric Co.
Leeds & Northrup
Leupold, Volpel & Co.
Linde Air Products Co.
Marsh Corp.
Mason-Neilan Regulator
Mercoid Corp.
Meriam Co.
Moeller Instrument Co.
Pittsburgh Equitable Met.
Precision Gage & Tool
Precision Therm. & Inst.
Preferred Utilities Mfg.
RCA Manufacturing Co.
Refinery Supply Co.
Republic Flow Meters
Rochester Mfg. Co.
Scientific Inst. Co.
Star Brass Mfg. Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.

GAGES, Pressure, Indicating (Cont'd)
Trerice Co.
Uehling Instrument Co.
United Cinephone Corp.
U. S. Gauge Co.
Victor Equipment Co.
Wagner & Son, Carl H.
Welch Mfg. Co.
Wilcus Manufacturing

GAGES, Pressure—Recording (See Gages, Pressure, Indicating)

GAGES, Pressure Temperature (See Gages, Pressure Indicating)

GAGES, Pressure, Tire
Air Balance Inst. Co.
U. S. Gauge Co.

GAGES, Pressure & Vacuum (See Gages, Pressure Indicating)

GAGES, Profile
Pratt & Whitney
Precision Gage & Tool
Sheffield Gage
Stockton Profile Gauge
United Cinephone Corp.

GAGES Radius
Lufkin Rule Co.
Starrett Co.
United Cinephone Corp.

GAGES, Rain (See Rain Gages)

GAGES, Rifle Bore
Hathaway Inst. Co.
Pratt & Whitney

GAGES, Ring
Brown & Sharpe
Greenfield Tap & Die
Morse Twist Drill
Pratt & Whitney
Precision Gage & Tool
Sheffield Gage
West & Dodge Thread
Zeiss, Inc., Carl

GAGES, Screw Thread
Brown & Sharpe
Federal Prod. Corp.
Greenfield Tap & Die
Lufkin Rule Co.
Millers Falls Co.
Pratt & Whitney
Reed Small Tool Works
Sheffield Gage
Starrett Co.
Union Tool Co.
West & Dodge Thread
Zeiss, Inc., Carl

GAGES, Sliding
Pratt & Whitney
Van Keuren Co.

GAGES, Snap
Brown & Sharpe
Gen. Engg. & Model Wks.
Greenfield Tap & Die
Meldrum-Gabrielson
Pratt & Whitney
Precision Gage & Tool
Sheffield Gage

UNITED STATES GAUGE COMPANY

INDICATING
AND RECORDING
PRESSURE
GAUGES

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for
Every Purpose

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VOLUMETRIC PRESSURE GAUGES,
Recording and Indicating

Write for complete information and catalogs.

Taylor Instrument Companies
ROCHESTER, N.Y. TORONTO, CANADA

For addresses, see pages 56-64

GAGES, Spline
Brown & Sharpe
Pratt & Whitney
Precision Gage & Tool
Sheffield Gage
GAGES, Star
Pratt & Whitney
GAGES, Strain
American Inst. Co.
Baldwin-Southwark
Binckley, G. S.
General Elec. Co.
Hathaway Inst. Co.
Holz, Herman A.
Olsen Testing Machine
Pratt & Whitney
Saxl Inst. Co.
Starrett Co.
GAGES, Surface
Ames Co., B. C.
Brown & Sharpe
Genales, Andrew
Federal Prod. Corp.
Lufkin Rule Co.
Millers Falls Co.
Saxl Inst. Co.
Starrett Co.
Zeiss, Inc., Carl
GAGES, Taper
Brown & Sharpe
Federal Prod. Corp.
Precision Gage & Tool
Pratt & Whitney
Sheffield Gage
Starrett Co.
GAGES, Telescoping
Brown & Sharpe
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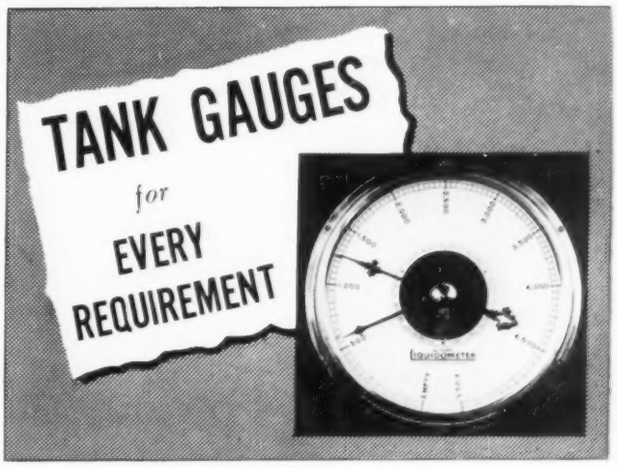

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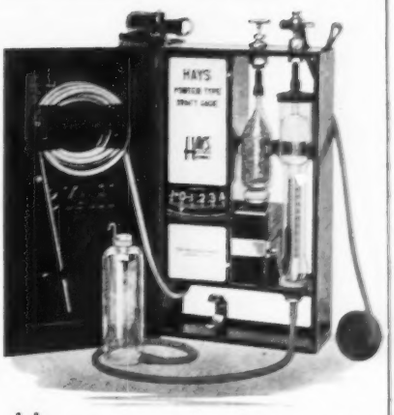

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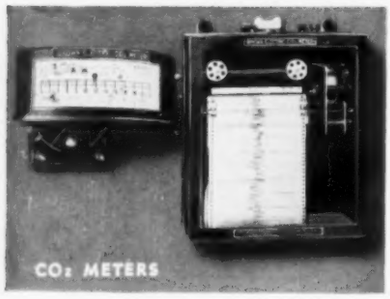

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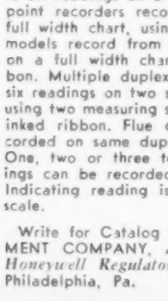

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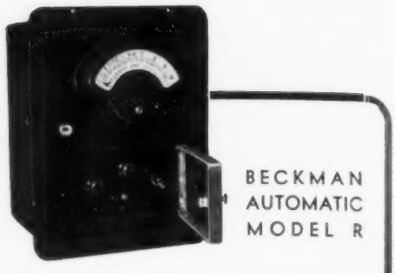

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HYGROMETERS (Hair, etc.) Indicating
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Bristol Co.
Brown Inst. Co.
Cambridge Inst. Co.
Central Scientific Co.
Consol. Albert & Hancock
Foxboro Co.
Fried & Lustig
Friez & Sons
Fuess, Inc.
Gierke & Co.
G. M. Mfg. Co., Inc.
Green, Henry J.
Huddleston, J. S. F.
Johnson Service Co.
Palmer Co.
Parks-Cramer Co.
Wagner & Son, Carl H.
Wayne-Nash Regulator

(Continued on next page)

GEOPHYSICAL APPARATUS

- Seismic
- Electrical
- Gravity
- Geothermal
- Magnetic
- Radioactive

GEOPHYSICAL INSTRUMENT CO.
WASHINGTON, D. C.

Taylor
HYDROMETERS
Write for complete information and catalogs.
Taylor Instrument Companies
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Taylor
HYGROMETERS
Write for complete information and catalogs.
Taylor Instrument Companies
ROCHESTER, N.Y. TORONTO, CANADA

For addresses, see pages 56-64

HYGROMETERS (Hair, etc.) Indicating (Cont'd)
Moeller Instrument Co.
Muter Company
Parks-Cramer Co.
Phila. Thermometer Co.
Precision Therm. & Inst.
Rieker Inst. Co.
Sargent & Co.
Scientific Inst. Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Wilder Sales Co.

HYGROMETERS, Recording
Bristol Co.
Brown Inst. Co.
Cambridge Inst. Co.
Consol. Ashcroft Hancock
Foxboro Co.
Friez & Sons
Fuess, Inc.
Green, Henry J.
Leeds & Northrup Co.
Mason-Neilan Regulator
Moeller Instrument Co.
Scientific Inst. Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.

HYGROSTATS
American Moistening Co.
Barber-Coleman Co.
Central Scientific Co.
Friez & Sons
Johnson Service Co.
Parks-Cramer Co.
Penn Elec. Switch Co.
Powers Regulator Co.

HYGRO-THERMOGRAPHS
Central Scientific Co.
Foxboro Co.
Fuess, Inc.
Friez & Sons
Green, Henry J.

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Central Scientific Co.
Keuffel & Esser Co.
Warren-Knight Co.

ICE WARNING Indicators
Kollsman Inst. Co.

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Hays Corp.
Southw'n Electronics Labs.

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Betts & Betts
Electronic Lab.
G-M Labs.
Luxtrol Co., Inc.
Paragon Electric Co.
Photobell Corp.
United Cinephone Corp.
Weston Elec. Inst. Corp.

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G-M Labs.
Leeds & Northrup Co.
Photobell Corp.
United Cinephone Corp.
Weston Elec. Inst. Corp.

ILLUMINATION RECORDERS
Esterline-Angus Co.
General Elec. Co.
United Cinephone Corp.

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INCLINOMETERS
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Kollsman Inst. Co.
Machlett & Son
Pioneer Instrument Co.
Precision Therm. & Inst.
Rieker Inst. Co.
Ruehfel Co.
Ruska & Co.
Starrett Co.
Warren-Knight Co.

INCLINOMETERS, Bore Hole
Sperry-Sun Well Surveying

INDEXES, Base Volume & Base Pressure
American Meter Co.

INDICATORS (Look under the object of measurement and control)

INDICATORS, Engine
American Inst. Co.
Bacharach Industrial Inst.
Baldwin-Southwark Corp.
Bendix Marine Products
Cambridge Inst. Co.

INDICATORS, Engine (Cont'd)
Commercial Engg. Labs.
Crosby Steam Gage Co.
McNab of Bridgeport
Pioneer Instrument Co.
Robertson, 3rd. J. L.
Star Brass Mfg. Co.
Trill Indicator Co.

INDICATORS, Engine Compression
Allen Elec. & Equip.
Bacharach Industrial Inst.
Baldwin-Southwark Corp.
Cambridge Inst. Co.
Commercial Engg. Labs.
G. M. CO Mfg. Co.
RCA Manufacturing Co.
Trill Indicator Co.

INDICATORS, Ignition Lag
American Inst. Co.

INDICATORS, Multiple Recording
Commercial Engg. Labs.

INDICATORS, Rate of Climb
American Askania Corp.
Kollsman Inst. Co.
Pioneer Instrument Co.
Rieker Inst. Co.

INDICATORS, Sound
Amperite Corp.
Clough-Brengle Co.
Daven Co.
Electronic Design Corp.
Jones-Orma Co.

INDUCTANCE METERS
Andrew, Victor J.
Industrial Instruments
Leeds & Northrup Co.
Premier Crystal Labs.
RCA Manufacturing Co.
Rubicon Co.
Shallcross Mfg. Co.
United Transformer Corp.

INSPECTION EQUIPMENT, Arc Welding
Rubicon Co.

INSPECTION DEVICES, AUTOMATIC, Concentricity
Federal Prod. Corp.
Luxtrol Co., Inc.

INSPECTION DEVICES, AUTOMATIC, Cylindricality
Federal Prod. Corp.
Luxtrol Co., Inc.

INSPECTION DEVICES, AUTOMATIC, Diameter
Instrument Specialties Co.
Luxtrol Co., Inc.
Gaertner Scientific Corp.

INSPECTION DEVICES, AUTOMATIC, Dimensions
Gaertner Scientific Corp.
Luxtrol Co., Inc.

INSPECTION DEVICES, AUTOMATIC, Hardness
Brabender Corp.
Detroit Testing Mach.
Holz, Herman A.
Saxl Inst. Co.

INSPECTION DEVICES, AUTOMATIC, Insulated Wire
Comtor Co.

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Physicists Research Co.
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Rubicon Co.

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Huisking & Co.
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Magnus, Mabee & Reynard
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Nye, Inc., William F

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Bunnell & Co.
Kellogg Switchboard
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Shallcross Mfg. Co.

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Roller-Smith Co.

KVA RECORDERS
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Therm-Electric Meters
Westinghouse Elec. & Mfg.

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Gorrell & Gorrell

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LABORATORY FURNITURE (See Furniture, Laboratory)

LABORATORY GLASSWARE (See Apparatus, Laboratory, Glass)

LABORATORY SUPPLIES (See Apparatus, Laboratory)

LABORATORY MOTORS (See Motors, Laboratory)

LABORATORY OVENS (See Ovens, Laboratory)

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Sargent & Co.
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Eimer & Amend
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Moeller Instrument Co.
Precision Therm. & Inst.
Rieker Inst. Co.
Ruth Glass Division
Ruenfel Co.
Schultheis Corp.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Trerice Co.
Welch Mfg. Co.
Zuhr, Inc., Henry

LAUNDER-OMETER
Atlas Elec. Devices Co.

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Chicago Dial Ind. Co.
Fuess, Inc.

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Clark & Sons
Perkin, Elmer & Moffitt

LENSES, Burette
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Fish-Schurman Co.
Fisher Scientific Co.
Gaertner Scientific Corp.
G. M. Mfg. Co., Inc.
Microchemical Service

LENSES, Burette (Cont'd)
Parr Instrument Co.
Precision Scientific Co.
Precision Therm. & Inst.
Rieker Inst. Co.

LENSES, Microscope, etc.
Bausch & Lomb Optical
Gaertner Scientific Corp.
Leitz, Inc.
Pfaltz & Bauer, Inc.
Spencer Lens Co.
Zeiss, Inc., Carl

LENSES, Polarized
Pfaltz & Bauer, Inc.
Polarizing Inst. Co.
Valpey Crystals
Woermann-Schuchhardt
Zeiss, Inc., Carl

LENSES, Thermometer (See Lenses, Burette)

LEVELS, Circular Spirit
Dietzen Co.
Geier & Bluhm, Inc.
Glogau & Co.
Gurley, W. & L. E.
Keuffel & Esser Co.
Ruehfel Co.
Warren-Knight Co.
White Co., Inc., David

LEVELS, Dumpy (See Surveying Instruments)

LEVELS, Engineer's (See Surveying Instruments)

LEVELS, Hand
Alpha Instrument Co.
Dietzen Co.
Gurley, W. & L. E.
Keuffel & Esser Co.
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Pittsburgh Inst. & Mach.
Starrett Co.
United States Blue Print
Warren-Knight Co.
Weber Co., F.
White Co. Inc., David

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Alpha Instrument Co.
Berger & Sons
Fish-Schurman Co.
Glogau & Co.
Gurley, W. & L. E.
Kern Co.
Keuffel & Esser Co.
Leupold, Volpel & Co.
Rieker Instrument Co.
Scherr Co., Inc.
Starrett Co.
Warren-Knight Co.
Weber Co., F.
White Co. Inc., David
Zeiss, Inc., Carl

LEVELS, Prism
Fecker, J. W.
Kern Co.
Keuffel & Esser Co.
Taylor Inst. Cos.
White Co. Inc., David

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LEVELS, Wye (See Surveying Instruments)

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Intercontinental Market.
Luxtrol Co., Inc.
Pfaltz & Bauer, Inc.
Photobell Corp.
Weston Elec. Inst. Corp.
Welch Mfg. Co.

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Barkon-Frink
General Physical Lab.

LIGHT SOURCES, "Daylight"
Barkon-Frink
Frober-Faybor Co.
General Elec. Co.
Macbeth Daylighting Co.
General Physical Lab.

LIGHT SOURCES, Incandescent
Barkon-Frink
Gaertner Scientific Co.
General Elec. Co.
General Physical Lab.
G-M Labs.
Leitz, Inc., E.
Luxtrol Co., Inc.
United Cinephone Corp.

LIGHT SOURCES, Mercury Vapor
American Inst. Co.
Barkon-Frink
Central Scientific Co.
Fish-Schurman Co.
Gaertner Scientific Corp.

LIGHT SOURCES, Mercury Vapor (Cont'd)
Gen. Elec. Lamp Dept.
General Physical Lab.
Hanovia Chem. & Mfg.
Leitz, Inc.
Mico Instrument Co.
Pfaltz & Bauer, Inc.
Polarizing Instrument
United Cinephone Corp.

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Central Scientific Co.
Fish-Schurman Co.
Fuess, Inc.
Gaertner Scientific Corp.
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General Physical Lab.
Mico Instrument Co.
Pfaltz & Bauer, Inc.
Polarizing Instrument
Van Keuren Co.
United Cinephone Corp.

LIGHT SOURCES, Neon
Barkon-Frink
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General Physical Lab.
United Cinephone Corp.

LIGHT SOURCES, Sodium
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Central Scientific Co.
Gaertner Scientific Corp.
Gen. Elec. Lamp Dept.
Leitz, Inc.
Pfaltz & Bauer, Inc.
United Cinephone Corp.
Zeiss, Inc., Carl

LIGHT SOURCES, Ultra-Violet
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Atlas Electric Devices
Central Scientific Co.
Gaertner Scientific Corp.
Co.
General Physical Lab.
Hanovia Chem. & Mfg.
Leitz, Inc.
Mico Instrument Co.
Pfaltz & Bauer, Inc.
United Cinephone Corp.
Westinghouse X-Ray Co.

LIGHT SOURCES, White Light
Barkon-Frink
Gaertner Scientific Corp.
Gen. Elec. Lamp Dept.
General Physical Lab.
United Cinephone Corp.

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Wallace-Tiernan

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LINEAR FOOTAGE METERS (See Counters, Footage)

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LIQUID METERS, POSITIVE TYPES (See Meters, Liq'd . . .)

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Foxboro Co.
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General Controls Co.
Hagan Corp.
Hanlon-Waters, Inc.
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Akatos, Inc.
Leitz, Inc.
Saxl Inst. Co.
United Cinephone Corp.

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MAGNETIC INSPECTORS (See Inspectors, Magnetic)

MAGNETOMETERS
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Baird Associates
Builders Iron Foundry
Cambridge Inst. Co.

MAGNETOMETERS (Cont'd)
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Precise Instrument Co.
Welch Mfg. Co.

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Fish-Schurman Co.
Fuess, Inc.
Glogau & Co.
G. M. Mfg. Co., Inc.
Keuffel & Esser Co.
Kollmorgen Optical Co.
Speidel & Co.
Spencer Lens Co.
Testrite Instrument Co.
Warren-Knight Co.
Weber Co., F.
Zeiss, Inc., Carl

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MANOMETERS, High Pressure
Daniel Orifice Fitting

MANOMETERS, Inclined Tube
American Blower Corp.
Bacharach Industrial Inst.
Bailey Meter Co.
Consol. Ashcroft Hancock
Defender Automatic Reg.
Detroit Air Meter Co.
Dwyer Mfg. Co.
Friez & Sons
Fuess, Inc.
Hays Corp.
H-B Inst. Co., Inc.
Meriam Co.
Precision Therm. & Inst.
Uehling Inst. Co.

MANOMETERS, Micro
Bacharach Industrial Inst.
Cambridge Inst. Co.
Fuess, Inc.
Welch Mfg. Co.

MANOMETERS, Remote-reading
Bailey Meter Co.
Brown Inst. Co.
Uehling Inst. Co.

MANOMETERS, Single-tube & Reservoir
Ace Glass Inc.
Bacharach Industrial Inst.
Bailey Meter Co.
Commercial Engg. Labs.
Connelly Iron Sponge Co.
Defender Automatic Reg.
Detroit Air Meter Co.
Dwyer Mfg. Co.
Gas Appliance Specialties
Lantz-Phelps Corp.
Meriam Co.
Morey & Jones, Ltd.
Precision Therm. & Inst.
Scientific Inst. Co.
Simplex Valve & Meter
Uehling Inst. Co.

MANOMETERS, U-tube, Electric Transmitting
Brown Inst. Co.
Bailey Meter Co.
Precision Therm. & Inst.
Southw'n Electronics Labs.

MANOMETERS, U-tube, Glass
Ace Glass, Inc.
Annis Co.
Bacharach Industrial Inst.
Builders Iron Foundry
Connelly Iron Sponge
Consol Ashcroft Hancock
Defender Automatic Reg.
Detroit Air Meter Co.
Dwyer Mfg. Co.
Eimer & Amend
Fish-Schurman Co.
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Halpern, Walter J.
Hays Corp.
Jensen Inst. Co.
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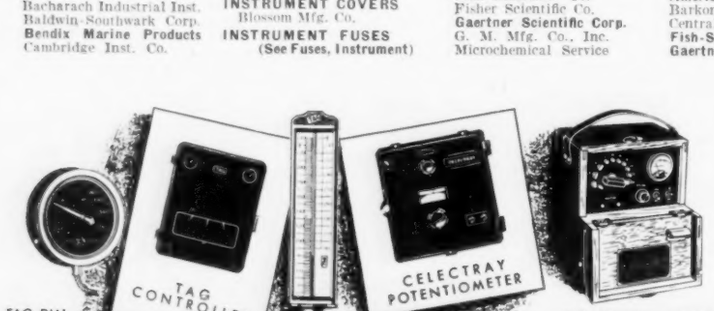
Macalaster Bicknell Co.
Machlett & Son
Meriam Co.
Mine Safety Appliances
Moeller Instrument Co.
Morey & Jones, Ltd.
Precision Therm. & Inst.
Rascher & Betzold



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Simplex Valve & Meter
Specialty Glass Co.
Tagliabue Mfg. Co.
Trerice Co.
Uehling Inst. Co.
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Wilkens-Anderson Co.

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Connelly Iron Sponge
Mason-Neilan Regulator
Precision Therm & Inst.
Scientific Inst. Co.
Taylor Inst. Cos.

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MARINE INSTRUMENTS, Gyro-Compass & Gyro-Pilot
Sperry Gyroscope Co.

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Ferner Co.
Fidelity Mach. Co.
Gaertner Scientific Corp.
Pratt & Whitney

MEASURING MACHINES, Wire
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Minneapolis Elec. & Const.
Pratt & Whitney

MEGOHMMETERS
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Cambridge Inst. Co.
Clough-Brengle Co.
General Elec. Co.
General Radio Co.
Ill. Testing Labs.
Industrial Instruments
Martindale Electric Co.
Rawson Electrical Inst.
RCA Manufacturing Co.
Sensitive Research Inst.
Shallcross Mfg. Co.
Stricht & Co.
Weston Elec. Inst. Corp.

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Corning Glass Works
Eimer & Amend
Ferner Co.
Fisher Scientific Co.
Humboldt Mfg. Co.
Machlett & Son
Microchemical Service
Parr Instrument Co.
Pfaltz & Bauer, Inc.
Precision Scientific Co.
Scientific Glass Apparatus
Tagliabue Mfg. Co.
Western Machinery Co.

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METALLIC BELLOWS (See Bellows, Metallic)

METALS, Thermostatic
Chace Co.
General Plate

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American Inst. Co.
Am. Paulin System
Friez & Sons

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Geophysical Instrument
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Green, Henry J.
Moeller Instrument Co.
Precision Therm. & Inst.
Taylor Inst. Cos.

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Robinson Orifice Fitting

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Lambert Meter Co.
Pgh. Equitable Meter Co.

METER STICKS
Lufkin Rule Co.
Weber Co.

METERS, Acid (See Acidimeters)

METERS, Ampere Hour (See Ampere Hour Meters)

METERS, Coal (See Coal Meters)

METERS, Compressed Air
American Meter Co.
Bailey Meter Co.
Mason-Neilan Regulator
N. J. Meter
Taylor Inst. Cos.

METERS, Condensation
Am. Dist. Steam Co.
Bailey Meter Co.
Buffalo Meter Co.
Central Station Steam
Henszey Co.
Taylor Inst. Cos.

METERS, Conductivity (See Conductivity Meters)

METERS, Consumer's, Electric
General Elec. Co.
Westinghouse Elec. & Mfg.

METERS, Consumer's, Gas
American Meter Co.
Lambert Meter Co., Inc.

METERS, Current, Air & Gas
American Meter Co.
Mason-Neilan Regulator
Pgh. Equitable Meter Co.

METERS, Current, Liquid
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Bowser & Co.
Builders Iron Foundry
Eclipse Aviation
Keuffel & Esser Co.
Mason-Neilan Regulator
National Meter Co.
Neptune Meter Co.
Pgh. Equitable Meter Co.
Scientific Inst. Co. (Calif.)
Uehling Instrument Co.
Worthington-Gamon Meter

METERS, Decibel (See Sound Level Meters)

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Esterline-Angus Co.
General Elec. Co.
HD Elec. Co.
Landis & Gyr, Inc.
Lincoln Meter Co.
Sangamo Electric Co.
Therm-Electric Meter Co.
Westinghouse Elec. & Mfg.

METERS, DEMAND, Gas
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Bailey Meter Co.
Bendix Marine Products
Lambert Meter Co.
Mason-Neilan Regulator
Pgh. Equitable Meter Co.

METERS, Demand Limiting, Automatic
American Meter Co.
Annis Co.
Esterline-Angus Co.
General Elec. Co.
Landis & Gyr, Inc.
Lincoln Meter Co.
Mason-Neilan Regulator
Therm-Electric Meter
Westinghouse Elec. & Mfg.

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Geophysical Inst. Co.
Rawson Electrical Inst.

METERS, Electronic
Ballantine Labs.
Cambridge Inst. Co.
Clough-Brengle Co.
Luxtrol Co., Inc.
RCA Manufacturing Co.
Weston Elec. Inst. Co.

METERS, Flow (See Flowmeters)

METERS, Footage (See Counters, Footage)

METERS, Foot-candle (See Foot-candle Meters)

METERS, Frequency (See Frequency Meters)

METERS, Gas (See Gas Meters)

METERS, Gas, Dry Test
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Lambert Meter Co.
Pgh. Equitable Meter Co.
Tagliabue Mfg. Co.

METERS, Gas, Integrating
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Bailey Meter Co.
Brown Inst. Co.
Foxboro Co.
Lambert Meter Co.
Mason-Neilan Regulator
Tagliabue Mfg. Co.
Taylor Inst. Cos.

METERS, Gas, Wet Test
American Meter Co.
Lambert Meter Co.
Tagliabue Mfg. Co.

METERS, Gas, Station
American Meter Co.
Bowser & Co.
Pgh. Equitable Meter Co.

METERS, Gasoline (See Meters, Liquid)

METERS, High Pressure & High Pressure Distribution
Pgh. Equitable Meter Co.
Simplex Valve & Meter

METERS, Hydrogen Ion (See Hydrogen Ion Determination Instruments)

METERS, LIGHT (See Foot-candle Meters, Illumination Indicators and Recorders, Light Meters, etc.)

METERS, Liquid, Volumetric Types, Nutating Disk
Badger Meter Co.
National Meter Co.
Neptune Meter Co.
Pgh. Equitable Meter
Read Machinery Co.
Worthington Gamon

METERS, Liquid, Volumetric Types, Nutating Piston
Buffalo Meter Co.
National Meter Co.
Neptune Meter Co.
Worthington Gamon

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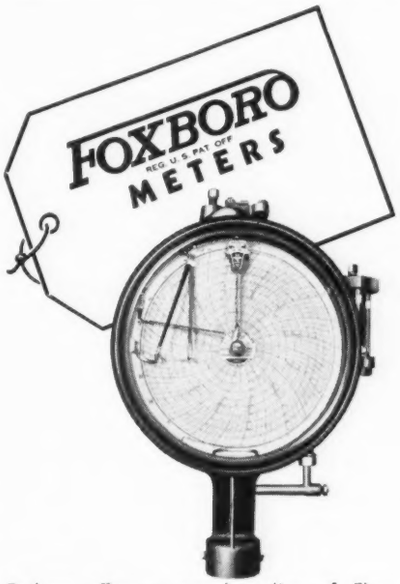

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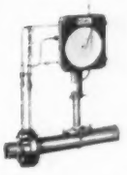

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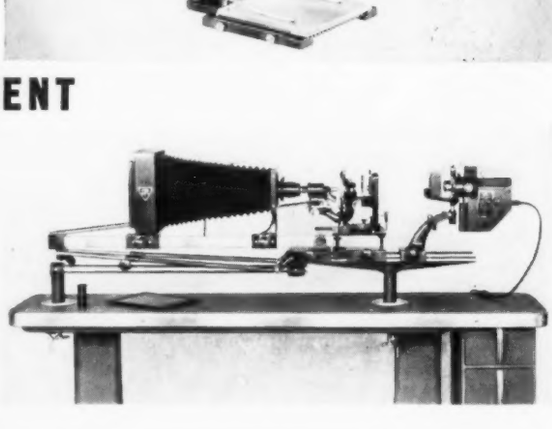

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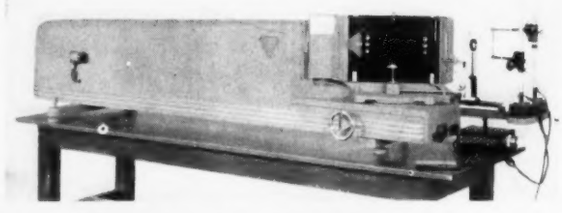

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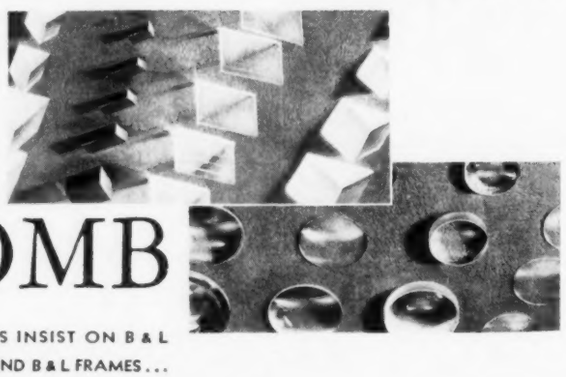

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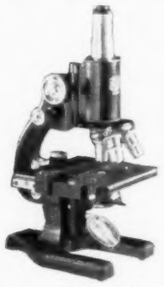

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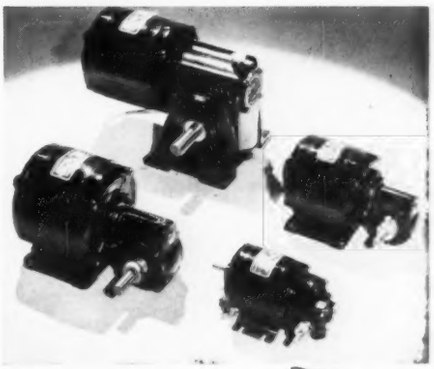

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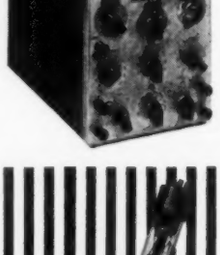

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Jones-Orme Co.
Raytheon Mfg. Co.
RCA Manufacturing Co.
Supreme Instruments
Triplett Electrical Inst.
Triumph Mfg. Co.
United Transformer Corp.

OSCILLOGRAPHS, Electrostatic
Cambridge Inst. Co.
RCA Manufacturing Co.

OSCILLOGRAPHS, High-vacuum Cathode-ray
Clough-Brengle Co.
DuMont Labs., Inc., A.B.
Electro-Medical Lab.
General Elec. Co.
Jones-Orme Co.
RCA Manufacturing Co.

OSCILLOGRAPHS, Moving-conductor
Baldwin-Southwark Corp.
Cambridge Inst. Co.
Geophysical Inst. Co.
Westinghouse Elec. & Mfg.

OSCILLOGRAPHS, Multi-element
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Cambridge Inst. Co.
Electro-Medical Lab.
Engineering Labs., Inc.
General Elec. Co.
Geophysical Inst. Co.
Ruska & Co., Inc.
Westinghouse Elec. & Mfg.

OSCILLOGRAPHS, Piezo-electric
Brush Development Co.
Cambridge Inst. Co.
McFarlin Co.

OSCILLOGRAPHS, Recording
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Brush Development Co.
Cambridge Instrument Co.
Electro-Medical Lab.
Engineering Labs., Inc.
General Electric Co.
Geophysical Instrument Co.
Hathaway Inst. Co.
Heiland Research Corp.
Jones-Orme Co.
Ruska & Co., Inc.
Sound Apparatus Co.
Triumph Mfg. Co.
Westinghouse Elec.

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Batcher, Ralph R.
Clough-Brengle Co.
DuMont Labs., Inc., A.B.
General Elec. Co.
General Radio Co.
Jackson Electrical Inst.
Jones-Orme Co.
RCA Manufacturing Co.
Ruska & Co., Inc.
Sundt Engg. Co.
Supreme Instruments
Thordarson Elec. Co.
United Transformer Corp.

OUTPUT METERS
Clough-Brengle Co.
Daven Co.
General Radio Co.
Jackson Electrical Inst.
Jones-Orme Co.
RCA Manufacturing Co.
Shaircross Mfg. Co.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

OVENS, Controlled atmosphere
Sodemann Heat & Power

OVENS, Crystal Oscillator
Bliley Electric Co.
Premier Crystal Labs.
Valpey Crystals

OVENS, Laboratory
Am. Gas Furnace
Bookel & Co.
Brabender Corp.
Braun Corp.
Central Scientific Co.
Dietert Co.
Elec. Heat Control App.
Falstrom Co.
Fish-Schurman Co.
Fisher Scientific Co.
General Combustion Corp.
Gordon Co.
Sargent & Co.
Sodemann Heat & Power
Thomas Co., Arthur H.
Welch Mfg. Co.
Williams Apparatus Co.

OVENS, Temperature
Central Scientific Co.
Falstrom Co.
Gordon Co.
Mason-Neilan Regulator

OVER & UNDER WEIGHT INDICATORS FOR BEAM SCALES
Howe Scale Co.
Jacobs Bros. Co., Inc.

OXYGEN ANALYZERS (See Gas Analyzers, Oxygen)

OXYGEN & NITROGEN TESTING APPARATUS (See Gas Analyzers, Oxygen & Nitrogen Apparatus)

PAINT HIDING POWER INSTRUMENTS (See Testers & Test. Mach., Paint)

PAINTS & INKS, For Emergency Heat Indicating
Efkalin Co.

PANELS, Instrument
Bailey Meter Co.
Beck Bros.
Brown Inst. Co.
Clough-Brengle Co.
Consol. Ashcroft Hancock
Daven Co.
Elec. Tachometer Corp.
Falstrom Co.
Foxboro Co.
General Elec. Co.
Hays Corp.
Hickok Elec. Inst.
Jones Motrola Sales
Karp Metal Products Co.
Marsh Corp.
Republic Flow Meters
Tagliabue Mfg. Co.
Triplett Electrical Inst.

PANELS, Radio Test
Burton-Rogers Co.
Clough-Brengle Co.
Daven Co.
Electronic Design Corp.
Falstrom Co.
Ferris Inst. Corp.
Hickok Elec. Inst. Co.
Jackson Electrical Inst.
Precision Apparatus Corp.
Triplett Electrical Inst.
Triumph Mfg. Co.

PANTOGRAPHS
Gaertner Scientific Corp.
Henschel & Co.
Keuffel & Esser Co.
Mico Instrument Co.
Speidel & Co.
Warren-Knight Co.
Weber Co.

PASSOMETERS
Keuffel & Esser Co.

WEBER CO.
Zeiss, Inc., Carl

PEDOMETERS
Keuffel & Esser Co.
Testrite Instrument Co.
Warren-Knight Co.
Weber Co.

PELLET PRESSES (See Presses, Pellet)

PELORUSES
Bliss & Co.
Keuffel & Esser Co.
Negus, T. S. & J. D.
Pioneer Instrument Co.
Precision Therm. & Inst.
Warren-Knight Co.

PENETROMETER NEEDLES (See Needles Penetrometer)

PERISCOPES, Industrial & Smoke
Ess Inst. Co.
Fecker, J. W.
Kollmorgen Optical Co.
Perkin, Elmer & Moffitt

PERISCOPES, Military & Naval
Fecker, J. W.
Keuffel & Esser Co.
Kollmorgen Optical Co.

PERMEAMETERS, Magnetic
Annis Co.
Cambridge Inst. Co.
Fisher Scientific Co.
General Electric Co.
Hathaway Inst. Co.
Leeds & Northrup Co.
Rubicon Co.
Welch Scientific Co.

PERMEAMETERS, Porosity
Cambridge Instrument
Engineering Labs., Inc.
Fisher Scientific Co.
Ruska & Co., Inc.
Saxl Instrument Co.

pH METERS (see Testers, Hydrogen Ion)

PHASE ANGLE METERS
Andrew, Victor J.
General Elec. Co.
Leeds & Northrup Co.
RCA Manufacturing Co.
Sensitive Research Inst.
Weston Elec. Inst. Corp.

PHASE INDICATORS
Andrew, Victor J.
RCA Manufacturing Co.

PHASE SEQUENCE INDICATORS
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Elec. Facilities Inc.
Ferranti Electric
General Elec. Co.
Meter Devices Co.
Sticht & Co.
Western Electro-Mech.

PHOSPHATE TESTERS (see Testers, Phosphate)

PHOTOELASTICITY POLARISCOPE (See Polariscope, Photoelasticity)

PHOTOELECTRIC CELLS (See Cells, Photoelectric)

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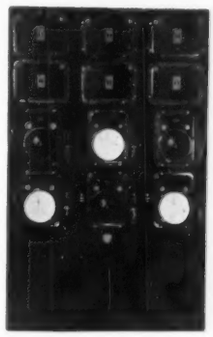

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Intercontinental Mrktng.
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Rhamstine, J. Thos.
Weston Elec. Inst. Corp.

PHOTOMETERS, Bar
Leeds & Northrup Co.
Gaertner Scientific Corp.

PHOTOMETERS, Candle
Connelly Iron Sponge

PHOTOMETERS, Flicker
Precision Therm. & Inst.

PHOTOMETER, Flicker Disc
Frober-Faybor Co.

PHOTOMETERS, Illumination
Akatos, Inc.
G-M Labs.
Leitz, Inc.

PHOTOMETERS, Micro
Akatos, Inc.
Baird Associates
Cambridge Inst. Co.
Gaertner Scientific Corp.
Hayes Scientific App.
Mico Instrument Co.

PHOTOMETERS, Neutral Wedge
American Inst. Co.
Gaertner Scientific Corp.

PHOTOMETERS, Photoelectric
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Cambridge Inst. Co.
Central Scientific Co.
Gaertner Scientific Corp.
General Elec. Co.
G-M Labs.
Intercontinental Mrktng.
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Pfaltz & Bauer, Inc.
Phipps & Bird, Inc.
Rubicon Co.
Southw'n Electronics Labs
Welch Mfg. Co.
Zeiss, Inc., Carl

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American Inst. Co.
Gaertner Scientific Corp.
Munsell Color Co.

PHOTOMETERS, Spectro
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American Inst. Co.
Frober-Faybor Co.
Fuess, Inc.
Gaertner Scientific Corp.
Pfaltz & Bauer, Inc.

PHOTOMETERS, Sphere
Akatos, Inc.
Leeds & Northrup Co.

PHOTOMETERS, Ultraviolet
Burt Scientific Labs.
Gaertner Scientific Corp.

PHOTO-MICROGRAPHIC EQUIPMENT (See Microscopes, Metallographic)

PHYSICAL TESTING MACHINES (See Testers and Testing Machines)

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Engineering Labs., Inc.
Geophysical Inst. Co.
McFarlin Co.
Water Leak Detector Co.

PIPETTES (See Apparatus, Laboratory, Glass)

PIPETTES, Mechanical (Equal Discharge)
Scientific Instr. (Calif.)

PISTOL BARREL OPTICAL TESTERS (See Tester, Pistol Barrel Optical)

PITOT TUBE METERS (See Flow Meters, Pitot Tube)

PITOT TUBES (see Flowmeters, Pitot Tube)

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Eastern Science Co.
Gurley, W. & L. E.
Kern Co.
Keuffel & Esser Co.
Speidel & Co.
Warren-Knight Co.
Weber Co.

PLANETARIUM
Eastern Science Co.
Fecker, J. W.
Zeiss, Inc., Carl

PLANIMETERS, Automatic Flow Record
Builders Iron Foundry
Robertson, 3rd., J. L.

PLANIMETERS, Linear
Bacharach Indus. Inst.
Keuffel & Esser Co.
Speidel & Co.
United States Blue Print
Warren-Knight Co.
Weber, Co.

PLANIMETERS, Radial
Bailey Meter Co.
Foxboro Co.
Keuffel & Esser Co.
Speidel & Co.
Trill Indicator Co.

PLANIMETERS, Square Root
Bailey Meter Co.
Foxboro Co.
Henschel & Co.
Keuffel & Esser Co.
Speidel & Co.
Taylor Inst. Cos.

PLUMB BOBS
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Brown & Sharpe
Dietzen Co.
Gurley, W. & L. E.
Keuffel & Esser Co.
Millers Falls Co.
Post Co., Frederick
Refinery Supply Co.
Soltmann, Inc.
Speidel & Co.
Starrett Co.
Ulmer Co., J. C.
Warren-Knight Co.
Weber Co.
White Co. Inc.

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Gaertner Scientific Corp.
Kern Co.
Leitz, Inc.
Pfaltz & Bauer, Inc.
Sargent & Co.
Zeiss, Inc., Carl

POLARISCOPE TUBES (See Tubes, Polariscope)

POLARISCOPES
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Gaertner Scientific Corp.
Pfaltz & Bauer, Inc.
Welch Mfg. Co.

POLARISCOPES, Photoelasticity
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Central Scientific Co.
Fecker, J. W.
Fuess, Inc.
Gaertner Scientific Corp.
Kollmorgen Optical Co.
Polarized Light & Photo.
Polarizing Instrument
Precision Therm. & Inst.
Woermann-Schuchhardt
Zeiss, Inc., Carl

POLARITY INDICATORS
Ruehfel Co.
Weston Elec. Inst. Corp.

POLARIZING PLATES
Central Scientific Co.
Fuess, Inc.
Polarized Products
Polarizing Instrument
Woermann-Schuchhardt
Zeiss, Inc., Carl

POLISHING MACHINES
American Inst. Co.
Eimer & Amend
Fisher Scientific Co.
Mico Instrument Co.

PORCELAIN, Laboratory
Akatos, Inc.
Coors Porcelain Co.
Fish-Schurmann Co.

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Fish-Schurman Co.

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Boston Auto Gage Co.
Builders Iron Foundry
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Electric Speed Ind.
Elec. Tachometer Corp.
Foxboro Co.
General Elec. Co.
Hickok Elec. Inst. Co.
Pioneer Instrument Co.
Shallcross Mfg. Co.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

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Autocall Co.
Bailey Meter Co.
Builders Iron Foundry
Elec. Indicator Corp.
Elec. Tachometer Corp.
Foxboro Co.
Westinghouse Elec. & Mfg.

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POTENTIAL DETECTORS (See Detectors, Potential)

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Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Coleman Elec. Co.
Dickson Co.
Foxboro Co.
Leeds & Northrup Co.

POTENTIOMETERS, Automatic Control (Cont'd)
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Mason Neilan Regulator
Spence Engineering Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Weston Elec. Inst. Corp.
Wheelco Inst. Co.

POTENTIOMETERS, Automatic Self Balancing
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Bristol Co.
Electronic Prod. Co.
Foxboro Co.
Leeds & Northrup Co.
Lewis Engg. Co.
Tagliabue Mfg. Co.
Weston Elec. Inst. Corp.

POTENTIOMETERS, Indicating
Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Cambridge Inst. Co.
Dickson Co.
Foxboro Co.
General Elec. Co.
Hellige, Inc.
J-B-T Instrs., Inc.
Leeds & Northrup Co.
Lewis Engg. Co.
Remler Co., Ltd.
Rubicon Co.
Tagliabue Mfg. Co.
Thwing-Albert Instrument
Wheelco Inst. Co.
Weston Elec. Inst. Corp.

POTENTIOMETERS, Recording
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Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Clarostat Mfg. Co.
Foxboro Co.
Leeds & Northrup Co.
Lewis Engg. Co.
Mason Neilan Regulator
Tagliabue Mfg. Co.
Thwing-Albert Instrument
United Cinephone Corp.

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General Elec. Co.
Hickok Elec. Inst. Co.
Leeds & Northrup Co.
Roller-Smith Co.
Sensitive Research Inst.
Westinghouse Elec. & Mfg.

POWER FACTOR RECORDERS
Esterline-Angus Co.
General Elec. Co.
Leeds & Northrup Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg.

POWER FACTOR REGULATORS
Allis-Chalmers Mfg.
Elec. Facilities Inc.
Leeds & Northrup Co.
Vaughn-G. E. Witt Co.

POWER-LEVEL INDICATORS
Clough-Brengle Co.
General Elec. Co.
General Radio Co.
Hickok Elec. Inst. Co.
Shallcross Mfg. Co.
Sound Apparatus Co.
Westinghouse Elec. & Mfg.

PRECISION-BORE GLASS TUBING
Ace Glass Inc.
Fischer & Porter
Fish-Schurman Co.
Scientific Glass

PRESSES, Laboratory
American Inst. Co.
Baldwin-Southwark Corp.
Central Scientific Co.
Eimer & Amend
Hydraulic Press Co.
Microchemical Service
Williams Apparatus

PRESSES, PELLET
Central Scientific Co.
Eimer & Amend
Hannifin Mfg. Co.
Parr Instrument Co.

PRESSURE CONTROLLERS, AUTOMATIC (See Controllers, Automatic, Pressure)

PRESSURE, High (Above 1000 lbs.) Indicators
Abercrombie Pump Co.
Area Regulators, Inc.
Atlas Valve Co.
Bailey Meter Co.
Baldwin-Southwark Corp.
Brooke Eng. Co.
Brown Inst. Co.
Crosby Steam Gage Co.
Fisher Governor Co.
Foxboro Co.
Heise Bourdon Tube Co.
Kollsman Inst. Co.
Kurman Electric Co.
Linde Air Products Co.
Marsh Corp.
Mason Neilan Regulator
McAlear Mfg. Co.
RCA Manufacturing Co.
Republic Flow Meters
Star Brass Mfg. Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Thrush & Co., H. A.
Trerice Co.

PRESSURE, HIGH (Above 1000 lbs.) Recorders
Bailey Meter Co.
Baldwin-Southwark Corp.
Bristol Co.
Brown Inst. Co.
Cambridge Inst. Co.
Cash Co.
Commercial Engg. Labs.
Crosby Steam Gage Co.
Dickson Co.
Esterline-Angus Co.
Foxboro Co.
Hydraulic Press Co.
Kurman Electric Co.
Linde Air Products Co.
Marsh Corp.
Mason-Neilan Regulator
Republic Flow Meters Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Trerice Co.

PRESSURE, HIGH (Above 1000 lbs.) Testing Devices
Bailey Meter Co.
Baldwin-Southwark Corp.
Crosby Steam Gage Co.
Foxboro Co.
Holz, Herman A.
Kurman Electric Co.
RCA Manufacturing Co.
Refinery Supply Co.
Walter Ruska & Co., Inc.
Star Brass Mfg. Co.

PRESSURE INDICATORS, Bellows
Autocall Co.
Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Crosby Steam Gage Co.
Defender Automatic Reg.
Dickson Co.
Hagan Corp.
Mason Neilan Regulator
Morey & Jones, Ltd.
Precision Therm. & Inst.
Tagliabue Mfg. Co.
Taylor Inst. Cos.

PRESSURE INDICATORS, Bourdon-tube
Bailey Meter Co.
Baldwin-Southwark Corp.
Bristol Co.
Brown Inst. Co.
Crosby Steam Gage Co.
Dickson Co.
Foxboro Co.
Halpern, Walter J.
Heise Bourdon Tube Co.
Hoke, Inc.
Kenyon Instrument Co.
Kollsman Inst. Co.
Marsh Corp., Jas. P.
Mason-Neilan Regulator
Republic Flow Meters
Star Brass Mfg. Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Trerice Co.

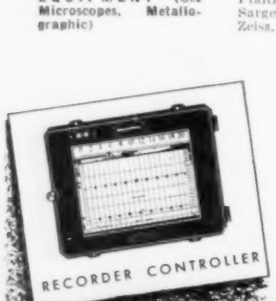
PRESSURE INDICATORS, Diaphragm, etc.
Abercrombie Pump Co.
Bailey Meter Co.
Brown Inst. Co.
Dickson Co.
Foxboro Co.
Hagan Corp.
King-Seeley Corp.
Kollsman Inst. Co.
Marsh Corp., Jas. P.
Mason-Neilan Regulator
Morey & Jones, Ltd.
Powers Regulator Co.
Rochester Mfg. Co.
Tagliabue Mfg. Co.

PRESSURE INDICATORS, Electrical-resistance
Baldwin-Southwark Corp.
General Elec. Co.
Hagan Corp.
Kurman Electric Co.
Rubicon Co.

PRESSURE INDICATORS, Inverted-bell
Bacharach Indus. Inst.
Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Dickson Co.
Foxboro Co.
Hagan Corp.
Mason Neilan Regulator
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Uehling Inst. Co.

PRESSURE INDICATORS, Membrane
Bailey Meter Co.
Dickson Co.
Mason-Neilan Regulator

PRESSURE INDICATORS, Piezoelectric
Batcher, Ralph R.
Brush Development Co.
Commercial Engg. Labs.
RCA Manufacturing Co.



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PRESSURE INDICATORS, Piston, Weight-loaded
American Inst. Co.
Bailey Meter Co.
Hagan Corp.

PRESSURE INDICATORS, Sing.e-tube, liquid column
Bacharach Indus. Inst.
Detroit Air Meter Co.
Dwyer Mfg. Co.
Gas App. Specialties
Morey & Jones, Ltd.
Precision Therm. & Inst.
Uehling Instrument Co.

PRESSURE INDICATORS, Sp.ing-loaded piston
Bacharach Indus. Inst.
Commercial Engg. Labs.
Hagan Corp.

PRESSURE INDICATORS, U-tube
Bacharach Indus. Inst.
Bailey Meter Co.
Connelly Iron Sponge
Consol. Ashcroft Hancock
Detroit Air Meter Co.
Dwyer Mfg. Co.
Friez & Sons
Gas App. Specialties
Halpern, Walter J.
Mason-Neilan Regulator
Meriam Co.
Moeller Instrument Co.
Morey & Jones, Ltd.
Precision Therm. & Inst.
Rennery Supply Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Trerice Co.
Uehling Instrument Co.

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Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Consol. Ashcroft Hancock
Dickson Co.
Esterline-Angus Co.
Mason-Neilan Regulator
Morey & Jones, Ltd.
Republic Flow Meters
Tagliabue Mfg. Co.
Taylor Inst. Cos.

PRESSURE RECORDERS, Bourdon tube
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Bris ol Co.
Brown Inst. Co.
Consol. Ashcroft Hancock
Dickson Co.
Esterline-Angus Co.
Foxboro Co.

PRESSURE RECORDERS, Bourdon Tube (Cont'd)
Improved Gauge Mfg. Co.
Kenyon Instrument Co.
Leeds & Northrup Co.
Marsh Corp., Jas. P.
Mason-Neilan Regulator
Morey & Jones, Ltd.
Republic Flow Meters
Star Brass Mfg. Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Thrush & Co., H. A.
Trerice Co.

PRESSURE RECORDERS, Capsular spring
Tagliabue Mfg. Co.

PRESSURE RECORDERS, Diaphragm
Bailey Meter Co.
Brown Inst. Co.
Foxboro Co.
Dickson Co.
Marsh Corp., Jas. P.
Mason-Neilan Regulator
Morey & Jones, Ltd.
Tagliabue Mfg. Co.

PRESSURE RECORDERS, Electrical-resistance
Republic Flow Meters

PRESSURE RECORDERS, Inverted-bell
Bacharach Indus. Inst.
Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Dickson Co.
Foxboro Co.
Leeds & Northrup Co.
Mason-Neilan Regulator
Taylor Inst. Cos.
Uehling Instrument Co.

PRESSURE RECORDERS, Membrane
Mason-Neilan Regulator

PRESSURE RECORDERS, Piezoelectric
Brush Development Co.
RCA Manufacturing Co.

PRESSURE RECORDERS, Piston, weight-loaded
Bailey Meter Co.

PRESSURE RECORDERS, Single-tube liquid column
Trerice Co.
Uehling Instrument Co.

PRESSURE RECORDERS, Spring-loaded piston
Bacharach Indus. Inst.
Baldwin-Southwark Corp.
Commercial Engg. Labs.
Esterline-Angus Co.

PRESSURE RECORDERS, U-tube
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Brown Inst. Co.
Foxboro Co.
Mason-Neilan Regulator
Republic Flow Meters
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Trerice Co.
Uehling Instrument Co.

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Brown Inst. Co.
Marsh Corp.
Martin Decker Corp.
McAlear Mfg. Co.
Meriam Co.
National Engg. Prods.

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Alpha Instrument Co.
Clark & Sons
Fish-Schurman Co.
Fecker, J. W.
Fuess, Inc.
Gaertner Scientific Corp.
Goerz Amer. Optical Co.
Kern Co.
Keuffel & Esser Co.
Kollmorgen Optical Co.
Machlett & Son
Master Optical Co.
Perkin Elmer & Moffitt
Rieker Inst. Co.
Spencer Lens Co.
Valpey Crystals
Woermann-Schuchhardt

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PROGRAM CLOCKS (See Timers, Automatic Process)

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Bausch & Lomb Optical
Bell & Howell Co.
Leitz, Inc.
Spencer Lens Co.
Woermann-Schuchhardt

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Leitz, Inc.
Spencer Lens Co.
Woermann-Schuchhardt
Zeiss, Inc.

PROTRACTORS, Bevel (See Drawing Instruments)

PROTRACTORS, Course
Alpha Instrument Co.
Bliss & Co.
Eastern Science Co.

PROTRACTORS, Course (Cont'd)
Kenyon Instrument Co.
Keuffel & Esser Co.
Marine Compass Co.
Negus, T. S. & J. D.
Pioneer Instrument Co.
Warren-Knight Co.

PROTRACTORS, Navigators (See Protractors, Course)

PROTRACTORS, Transparent (See Drawing Instruments)

PROVERS, Gas Meter
Lambert Meter Co., Inc.
Pittsburgh Equit. Meter

PROVERS, Water Meter
Pittsburgh Equit. Meter

PROVING RINGS
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Holz, Herman A.
Morehouse Machine Co.
Olsen Testing Machine
Pittsburgh Inst. & Mach.

PSYCHOLOGY LABORATORY APPARATUS
Batcher, Ralph R.
Brush Development Co.
Electro-Medical Lab.
General Radio Co.
Phipps & Bird, Inc.

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American Moistening Co.
Friez & Sons
Fuess, Inc.
G. M. Mfg. Co., Inc.
H-B Inst. Co., Inc.
Mason-Neilan Regulator
Moeller Instrument Co.
Palmer Co.

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Parks-Cramer Co.

PSYCHROMETERS, Electric (See Psychrometers, Aspiration)

PSYCHROMETERS, Recording (See Hygrometers, Recording)

PSYCHROMETERS, Sling
Accuracy Scientific Inst.
American Inst. Co.
American Moistening Co.
Central Scientific Co.
Chicago Apparatus Co.
Foxboro Co.
Fried & Lustig
Friez & Sons
Fuess, Inc.
G. M. Mfg. Co., Inc.

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Green, Henry J.
H-B Inst. Co., Inc.
Huddleston, J. S. F.
Johnson Service Co.
Moeller Instrument Co.
Palmer Co.
Parks-Cramer Co.
Phila. Thermometer Co.
Precision Therm. & Inst.
Scientific Inst. Co.
Taylor Inst. Cos.
Trerice Co.
Warren-Knight Co.

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Chicago Apparatus Co.
Fisher Scientific Co.
Hellige, Inc.
LaMotte Chemical Prod.
Precision Scientific Co.
Rieker Inst. Co.
Rubicon Co.
Scientific Glass App.
Taylor & Co., Inc., W. A.

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Central Scientific Co.
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Distillation Prods., Inc.
Machlett & Son
Nelson, George F.
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Scientific Glass App.
Sterling Eng. Co.
Welch Mfg. Co.

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G. M. Mfg. Co.
Rascher & Betzold
Specialty Glass Co.

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Cambridge Inst. Co.
Eppley Lab.
Leeds & Northrup Co.

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Cambridge Inst. Co.
Foxboro Co.
Leeds & Northrup Co.
Lewis Engineering
Rubicon Co.
Tagliabue Mfg. Co.
Thwing-Albert Inst. Co.

PYROMETERS, Electrical Resistance
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Cambridge Inst. Co.
Dickson Co.
Foxboro Co.
General Elec. Co.
Ill. Testing Labs.
J-B-T Instrs., Inc.
Leeds & Northrup Co.
Lewis Engg. Co.
Roller-Smith Co.
Rubicon Co.
Tagliabue Mfg. Co.
Thwing-Albert Inst. Co.
Wheelco Inst. Co.

PYROMETERS, Expansion
Defender Automatic Reg.
Ferner Co.
Partlow Corp.
Tagliabue Mfg. Co.

PYROMETERS, Indicating
Bacharach Indus. Inst.
Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Burling Inst. Co.
Electronic Prod. Co.
Engelhard, Chas.
Foxboro Co.
Ill. Testing Labs.
Leeds & Northrup Co.
Lewis Engg. Co.
Partlow Corp.
Pyrometer Inst. Co.

PYROMETERS, Indicating (Cont'd)
Roller-Smith Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Thwing-Albert Instrument
Wheelco Inst. Co.

PYROMETERS, Millivoltmetric
Am. Gas Furnace Co.
Bristol Co.
Brown Inst. Co.
Cambridge Inst. Co.
Engelhard, Chas.
Foxboro Co.
Hoskins Mfg. Co.
Ill. Testing Labs.
Pyrometer Instrument Co.
Rubicon Co.
Taylor Inst. Cos.
Thwing-Albert Instrument
Wheelco Inst. Co.

PYROMETERS, Optical
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Brown Inst. Co.
Cambridge Inst. Co.
Fisher Scientific Co.
Leeds & Northrup Co.
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Available in a number of double range combinations, such as 1 volt and .1 volt, 100 MV and 10 MV, also in pH ranges. Guaranteed accuracy .1%. *An outstanding value.*

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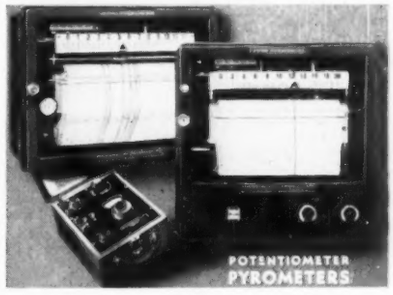

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BROWN PYROMETERS
AND
MINNEAPOLIS-HONEYWELL CONTROL SYSTEMS
To Measure and Control is to Economize

For addresses, see pages 56-64

Pyrometers . . . CONTROLLING RECORDING INDICATING

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Rubicon Co.
Tagliabue Mfg. Co.
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Dickson Co.
Foxboro Co.
J-B-T Insts., Inc.
Leeds & Northrup Co.
Lewis Engg. Co.
Rubicon Co.
Tagliabue Mfg. Co.
Thwing-Albert Instrument
Wheelco Inst. Co.

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Bacharach Indust. Inst.
Bailey Meter Co.
Brown Inst. Co.
Cambridge Inst. Co.
Engelhard, Chas.
Foxboro Co.
General Elec. Co.
Ill. Testing Labs.
Leeds & Northrup Co.
Tagliabue Mfg. Co.
Thwing-Albert Instrument
Wheelco Inst. Co.

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Bristol Co.
Brown Inst. Co.
Cambridge Inst. Co.
General Elec. Co.
Leeds & Northrup Co.
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Tagliabue Mfg. Co.
Taylor Inst. Cos.
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Brown Inst. Co.
Cambridge Inst. Co.
General Elec. Co.
Leeds & Northrup Co.
Pyrometer Instrument Co.
Tagliabue Mfg. Co.
Thwing-Albert Instrument

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Brown Inst. Co.
Cambridge Inst. Co.
General Elec. Co.
Ill. Testing Labs.
J-B-T Insts., Inc.
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Lewis Engg. Co.
Partlow Corp.
Pyrometer Inst. Co.
Roller-Smith Co.
Tagliabue Mfg. Co.
Thwing-Albert Instrument
Woermann-Schuchhardt

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Bailey Meter Co.
Bristol Co.
Brown Inst. Co.
Cambridge Inst. Co.
Foxboro Co.
Hebler Co.
Hoskins Mfg. Co.
Ill. Testing Labs.
J-B-T Insts., Inc.
Leeds & Northrup Co.
Lewis Engg. Co.
Partlow Corp.
Pyrometer Instrument Co.
Roller-Smith Co.
Rubicon Co.
Scientific Inst. Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Thwing-Albert Instrument
Wheelco Inst. Co.

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Bailey Meter Co.
Beck Co.
Bristol Co.
Brown Inst. Co.
Cambridge Inst. Co.
Engelhard, Chas.
Foxboro Co.
General Elec. Co.
Ill. Testing Labs.
Leeds & Northrup
Lewis Engg. Co.
Mason-Neilan Regulator
Partlow Corp.
Pyrometer Instrument Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Thwing-Albert Instrument

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Bristol Co.
Brown Inst. Co.
Cambridge Inst. Co.
Foxboro Co.
General Elec. Co.
Ill. Testing Labs.
Lewis Engg. Co.
Pyrometer Instrument Co.
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Thwing-Albert Instrument

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Hanovia Chem. & Mfg.
Thermal Syndicate Ltd.

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RADIO-MICROMETERS (See Micrometers, Radio)

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McFarlin Co.
RCA Manufacturing Co.
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RADIO TUBE CHECKERS (See Checkers, Radio Tube)

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Precision Therm. & Inst.
Taylor Inst. Cos.
Warren-Knight Co.
White Co., Inc.

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Friez & Sons
Fuess, Inc.
Green, Henry J.
Leupold, Volpel & Co.
Taylor Inst. Cos.

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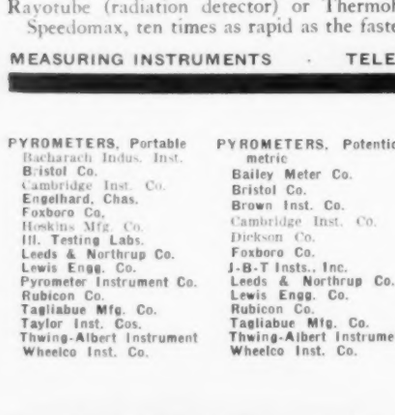
Gaertner Scientific Corp.
Kern Co.
Keuffel & Esser Co.
Kollmorgen Optical Co.
Leitz, Inc.
Precision Therm. & Inst.
White Co., Inc.



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A direct-reading, simple and sturdy pyrometer, especially suited for industrial applications where simplicity and ruggedness are of greater importance than extreme accuracy. The instrument can be calibrated to compensate for long lengths of extension lead wire between thermocouples and instrument. No dry cells or standard cells required.

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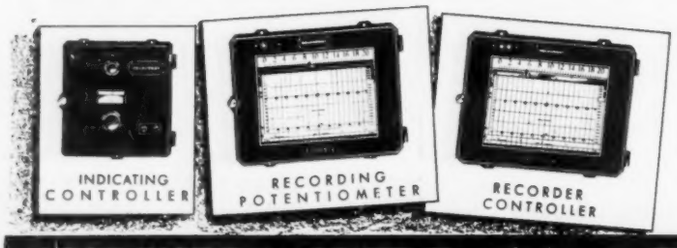

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Premier Crystal Labs.
Rubicon Co.
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Benwood Linze Co.
General Elec. Co.
Raytheon Mfg. Co.
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United Transformer Corp.
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Allis-Chalmers Mfg.
Applied Research Labs.
Eclipse Aviation
Electro Products Labs.
General Elec. Co.
Raytheon Mfg. Co.
United Transformer Corp.
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Electrons, Inc.
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Hy-Ef Elec. Products
Jones-Orme Co.
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Leeds & Northrup Co.
Woermann-Schuchhardt
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Baird Associates
Bausch & Lomb Optical
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Fuess, Inc.
Perkin, Elmer & Moffitt
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Black-Ray Lighting Co.
REFLECTORS, Concave
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Baird Associates
Bausch & Lomb Optical
Clark & Sons
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Fish-Schurman Co.
Fuess, Inc.
Perkin, Elmer & Moffitt
Tinsley Labs.

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Baird Associates
Bausch & Lomb Optical
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Fish-Schurman Co.
Fuess, Inc.
Master Optical Co.
Perkin, Elmer & Moffitt
Tinsley Labs.
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Fuess, Inc.
Perkin, Elmer & Moffitt
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Perkin, Elmer & Moffitt
Tinsley Labs.
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Bausch & Lomb Optical
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Fuess, Inc.
Perkin, Elmer & Moffitt
Tinsley Labs.

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Fuess, Inc.
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Northern Equip. Co.
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Partlow Corp.
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Penn Electric Switch Co.
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Preferred Utilities Mfg.
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Ruggles-Klingemann
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Mason-Neilan Regulator
Parks-Cramer Co.
Powers Regulator Co.
Robertshaw Thermostat
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Askania Regulator Co.
Bailey Meter Co.
Brooke Eng. Co.
Brown Inst. Co.
Cash Co.
Connelly Iron Sponge
Fisher Governor Co.
Foster Engg. Co.
Foxboro Co.
General Regulator Corp.
Hagan Corp.
Hays Corp.
Hanlon-Waters, Inc.
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McAlear Mfg. Co.
McDonnell & Miller
National Brass Co.
Natural Gas Equipment
Penn Electric Switch
Perfex Corp.
Republic Flow Meters
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Wilgus Mfg. Co.

(Continued on page 34)

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aside from furnace or kiln temperature. Does not require skilled operator. Stock ranges 1000° to 3600° F.

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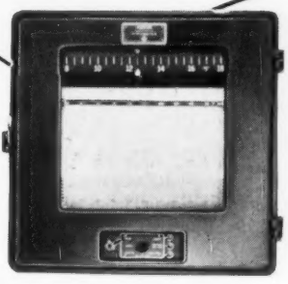
311 ROSS ST., PITTSBURGH, PA.

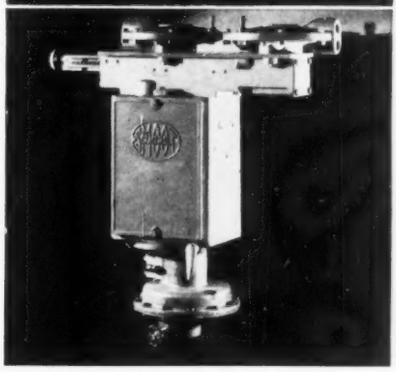
FOXBORO REG U.S. PAT. OFF **PYROMETERS**



The Foxboro Pyrometer line embraces a variety of types including Indicators, Controllers and Recorder Controllers. Single and multiple recording instruments up to eight records on one chart are available. The Recorder Controller is made in several types, both air- and electrically-operated, to fill practically every conceivable need.

For complete information write for Bulletin No. 190-3. The Foxboro Company, 46 Neponset Avenue, Foxboro, Mass., U.S.A. Branch offices in 25 Principal Cities.

REGULATORS

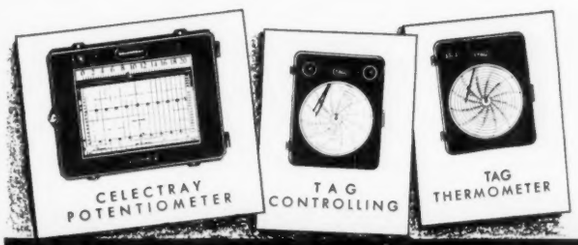


Republic-Smoot regulators are supplied for the automatic control of pressure, rate of flow, speed of rotation, level of a liquid or the proportioning of two pressures, flows, etc., in a fixed ratio by mechanically operating a valve, damper, rheostat or various types of variable speed transmissions.

Republic-Smoot regulators may be either oil or air operated. Their extreme flexibility in application and the degree to which they meet the four requirements of sensitivity, power, speed and stability, had been responsible to a large degree for the outstanding success of Republic-Smoot control systems.

WRITE FOR DATA BOOK No. S-13

REPUBLIC FLOW METERS CO.
2249 DIVERSEY PKWY., CHICAGO, ILLINOIS



TAG RECORDERS

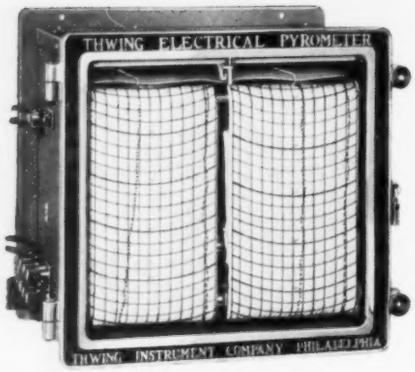
These instruments are designed to record all temperatures from minus 200°C. up, and all industrial pressures. Ask for Catalogs—They graphically suggest the usefulness of TAG TEMPERATURE RECORDERS and PRESSURE RECORDERS for service and economy in your plant.

C. J. TAGLIABUE MFG. CO.
Park & Nostrand Aves., Brooklyn, N. Y.

LOOK INSIDE the COVER (Part 1) *See How* TAG RECORDERS *Save You Money* TAG

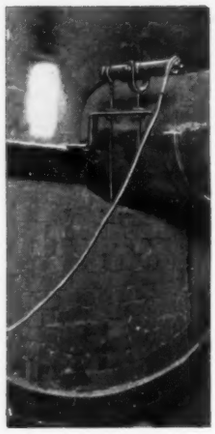
For addresses, see pages 56-64

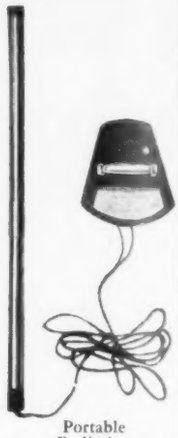
THWING-ALBERT Plant nd



Multiple Recording Pyrometer

Indicating Pyrometer combined with Selector Switch


Radiation Pyrometer for Rotary Kiln


Portable Radiation Pyrometer

Treasure Chest Pyrometer and Thermocouple Testing Set

TEMPERATURE MEASURING, CONTROL AND TESTING INSTRUMENTS

RECORDING PYROMETERS: Single record and multiple recording types. Continuous roll charts. Automatic chart re-roll. Patented dot and dash system of recording. Synchronous electric motor drive. Metal case construction. Accurate, simplified and rugged.

Furnished for use with either base metal or platinum thermocouples, radiation pyrometer receiving tubes or electrical resistance thermometer bulbs.

INDICATING PYROMETERS: Single indicating type or multiple point indicating type. Model 30 Pyrometer, illustrated, unit construction. Indicating Pyrometer and selector switch contained in a single moisture, fume and dust-proof metal case. Furnished with switch capacities 4, 6, 8, 12, 16, 24 and 32 points and off position. Suitable especially for diesel engine service, ceramic plants, etc.

RADIATION PYROMETERS: For indicating and recording all high temperatures. No part of pyrometer installed in the heat source. Accurate to the highest temperatures. Radiation receiving tubes are designed and manufactured for permanent installation. Suitable especially for the lime, cement, refractories, glass and steel industries. Portable radiation pyrometer applicable for various service. Temperature readings in 15 seconds.

A5X Pyrometer for molten non-ferrous metals

FOUNDRY PYROMETERS: For non-ferrous metals; A5X Pyrometer with extensible magazine thermocouple. Junctions made by twisting wires together tightly. Temperature readings in 8 seconds.

For ferrous metals; A5F Pyrometer with protected, replaceable thermocouple. Temperature readings in one minute.

PYROMETER TESTING SET: Treasure Chest, a two point portable potentiometer and a pyrometer and thermocouple testing set combined in the one instrument.

Self checking with Electrocrit checking circuit. Range 101 millivolts. Accuracy 1/10 of one percent. Checks all types and all makes of pyrometers and thermocouples.

THERMOCOUPLES: Base Metal and Noble Metal (Platinum, platinum-rhodium).

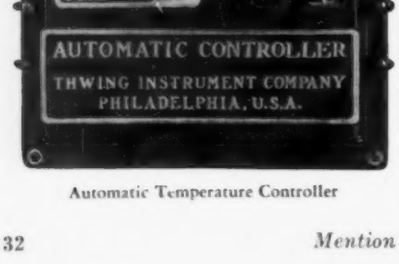
Furnished with protection tubes to suit individual installation conditions.

AUTOMATIC TEMPERATURE CONTROLLER: Controls automatically and accurately industrial temperature processes. Furnished for operation in conjunction with recording and indicating pyrometers. Applicable to oil, gas and electrically heated furnaces.

PORTABLE pH METERS: Range 0 to 14 pH. Direct reading in pH units.

Model 1 — Simple potentiometric circuit using quinhydrone or antimony electrodes.

Model 2 — Vacuum tube potentiometric circuit using glass electrodes and/or quinhydrone and antimony electrodes.



Automatic Temperature Controller

Portable pH Meter

Thwing-Albert Instrum

Manufacturers of Scientrum

3323 LANCASTER AVE. P

Commercial Instrumentatory Acc

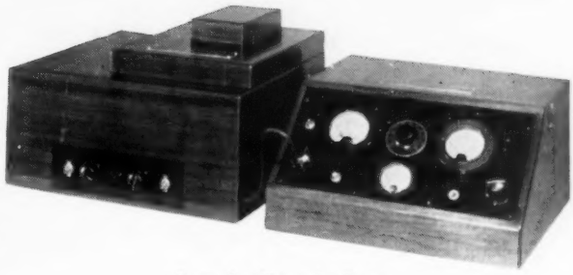
Catalogs Available on Complete Lines and Pa

nd Laboratory Instruments

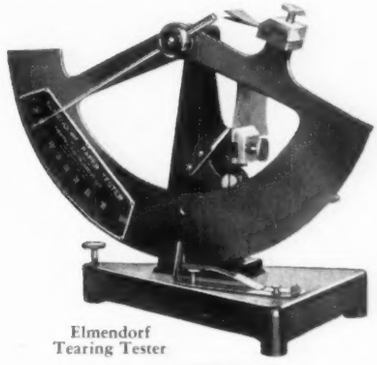
Platinum Thermo-couple

Electro Hydraulic Tensile Tester

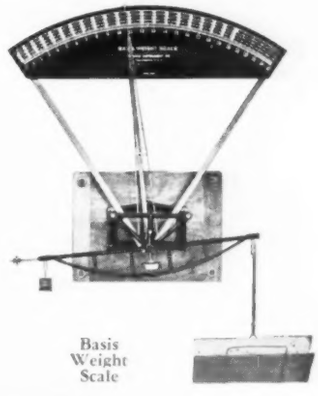
Research Tearing Tester



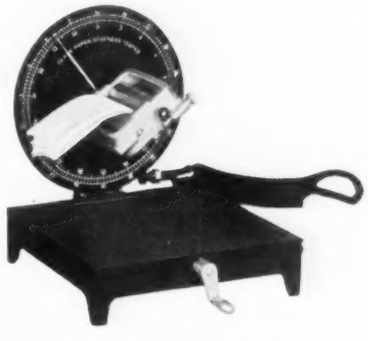
Formation Tester for Paper



Elmendorf Tearing Tester



Basis Weight Scale



Stiffness-Softness Tester for Paper

ELECTRO-HYDRAULIC TENSILE TESTER: For testing paper, textiles, fine wire, single thread, skein yarn, card board, ply wood, etc. Tensile and elongation tests made to conform with A.S.T.M. and T.A.P.P.I. official testing methods. Operated by electro-hydraulic power. Completely self-contained. Can be furnished with graphic recording device to record tensile stress and elongation of individual specimens.

PAPER TESTING INSTRUMENTS.

ELMENDORF TEARING TESTER: Determines tearing strength of paper and allied products, textile fabrics, cinema film, etc. Operates by gravity. Gives readings in force grams required to tear materials. Standard tearing tester of paper industry.

RESEARCH TEARING TESTER: For research and exploratory testing of materials where sensitivity desired is finer than calibration of the standard Elmendorf Tearing Tester.

INITIAL TEAR TESTER (not illustrated): Measures the initial force required to start a tear. Direct reading, resistance to beginning of tear is indicated in force pounds. Especially suitable for testing box board, roofing felts, floor coverings, gasket papers, etc.

BASIS WEIGHT SCALES: Aristocrat Model and Desk Type.
Basis Weight Scales read directly weight per ream of paper by weighing a single sheet. Furnished with ranges to suit individual requirements. Useable for moisture content determinations.

BOX BOARD SCALES: A combination basis weight and sheet counting scale. Indicates on a single dial weight per ream and sheets per bundle.

PENETRATION TESTER: The Penescope provides visual method of testing papers and other materials for permeability to solutions.
Also, Water Jacketed Penescope with equipment to make penetration tests under controlled temperature conditions.

VAPOR TRANSMISSION TESTER: The Vapometer, a simple convenient instrument for testing the vapor transmission properties of paper.

STIFFNESS-SOFTNESS TESTER: Determines stiffness or softness properties by the flexibility of paper in a predetermined angle of rotation.
Research Tester has rollers to adjust length of specimen.
Routine Tester has snap clamp for tests on specimens of known length.

FORMATION TESTER: Measures objectively the property of paper known as Formation. Test specimen in scanning mechanism is moved at high velocity between photo electric cell and light source.
Variations in paper structure (formation) determined electrically. Reading on meter gives formation number. Constructed ruggedly. Simple to operate.

Penescope Penetration Tester

Vapometer Vapor Transmission Tester

Desk Type Basis Weight Scale

nstrument Co.

ien truments for 38 Years

PHILADELPHIA, U. S A.

Inst atory Accuracy

t and Paper Testing Instruments

Taylor

"FULSCOPE" Indicating Temperature & Pressure Controllers

Write for complete information and catalogs.

Taylor Instrument Companies

ROCHESTER, N.Y. TORONTO, CANADA

Taylor

"FULSCOPE" LIQUID LEVEL CONTROLLERS

Write for complete information and catalogs.

Taylor Instrument Companies

ROCHESTER, N.Y. TORONTO, CANADA

REGULATORS, AUTOMATIC, Compressed Gas
American Meter Co.
Bailey Meter Co.
Brooke Eng. Co.
Brown Inst. Co.
Cash Co.
Dockson Co.
Electrimatic Corp.
Fisher Governor Co.
Frick Co.
Hanlon-Waters, Inc.
Hoke, Inc.
Linde Air Products Co.
Mason-Neilan Regulator
McAlear Mfg. Co.
Mercon Regulator Co.
Natural Gas Equipment
Pgh. Equitable Meter
Republic Flow Meters
Reynolds Gas Regulator
Robertshaw Thermostat
Tagliabue Mfg. Co.
Victor Equipment Co.

REGULATORS, AUTOMATIC, Condensation (See Controllers, Automatic, Condensation)

REGULATORS, AUTOMATIC, Consistency (Paper & Pulp) (See Controllers, Automatic, Consistency)

REGULATORS, AUTOMATIC, Current
Allis-Chalmers Mfg. Co.
Amperite Corp.
Beck Bros.
Betts & Betts
Burlington Inst. Corp.
Cutler-Hammer, Inc.
General Elec. Co.
Monitor Controller Co.
Robertshaw Thermostat
Roller-Smith Co.

REGULATORS, AUTOMATIC, Damper (See Controllers, Automatic, Damper)

REGULATORS, AUTOMATIC, District (See Governors, District)

REGULATORS, AUTOMATIC, Draft (See Controllers, Automatic, Draft)

REGULATORS, AUTOMATIC, Drying Chamber
Powers Regulator Co.
United Cinephone Corp.

REGULATORS, AUTOMATIC, Feed Water
Askania Regulator Co.
Atlas Valve Co.
Bailey Meter Co.

REGULATORS, AUTOMATIC, Feed Water (Cont'd)
Brown Inst. Co.
Cochrane Corp.
Davis Reg. Co.
Defender Automatic Reg.
General Regulator Corp.
Hagan Corp.
Hanlon-Waters, Inc.
Mason-Neilan Regulator
McAlear Mfg. Co.
McDonnell & Miller
Mercon Regulator Co.
Natural Gas Equipment
Northern Equip. Co.
Ruggles-Klingemann
Stets Co.
Tagliabue Mfg. Co.
Vaughn-G E. Witt Co.
Watts Regulator Co.
Wilgus Mfg. Co.
Williams Gauge Co.

REGULATORS, AUTOMATIC, Flow (See Controllers, Automatic, Flow)

REGULATORS, AUTOMATIC, Flow Proportioning (See Controllers, Automatic, Flow Proportioning)

REGULATORS, AUTOMATIC, Fluid Proportioning (See Controllers, Automatic, Fluid Proportioning)

REGULATORS, AUTOMATIC, Frequency
Burlington Inst. Corp.
General Elec. Co.
Warren Telechron Co.
Wheelco Inst. Co.

REGULATORS, AUTOMATIC, Furnace (See Controllers, Automatic, Furnace)

REGULATORS, AUTOMATIC, Gas (See Regulators, Automatic, Air)

REGULATORS, AUTOMATIC, Humidity (See Controllers, Automatic, Humidity)

REGULATORS, AUTOMATIC, Liquid Level (See Controllers, Automatic, Liquid Level)

REGULATORS, AUTOMATIC, Load
Allis-Chalmers Mfg. Co.
Autom'c Valve Controller
Hays Corp.
Leeds & Northrup Co.

CONSTANT VOLTAGE

FOR YOUR LABORATORY . . . FOR YOUR PRODUCTION LINE . . . OR INCORPORATED IN YOUR PRODUCTS

Whether it's 1 VA for an instrument or 10 KVA for a production line—if your needs call for stable voltage at all times, SOLA CONSTANT VOLTAGE TRANSFORMERS will deliver for you.

Fully automatic, instantaneous in operation, SOLA CONSTANT VOLTAGE TRANSFORMERS have no moving parts and require no maintenance. They are self-protecting and cannot be damaged by short circuit. AND—they will maintain their output voltage to within a fraction of a percent of the specified value, even though the line voltage varies *as much as thirty percent.*

You can build a SOLA CONSTANT VOLTAGE TRANSFORMER into your product and stop worrying about your customer's line voltage. There will be no burn-outs from over-voltage, no operating failures due to under-voltage and no erratic performance resulting from line transients.

For capacities above 200 VA. Housing type.

You can build a SOLA CONSTANT VOLTAGE TRANSFORMER into your production line or your laboratory and know that every test will be made under the same line conditions, that those conditions will not change from the start of your test to its finish, and, above all, that if a short circuit occurs, there will be no fires, no ruined transformer, no blown fuses.

From 20—200 VA. Primary cord set, and output receptacle.

You'll find these SOLA CONSTANT VOLTAGE TRANSFORMERS surprisingly compact—and economical, too. To augment or replace non-regulating types, standard designs are available, or units can be built to your special specification. So—whether it's 1 VA for an instrument or 10 KVA for a production line—make it a SOLA and be sure! Our engineers will assist you in selecting the type best suited to your needs. *Write for Bulletin SM-22A1.*

A new unit for applications up to 15 VA. Equipped with leads or terminals.

SOLA

SOLA ELECTRIC CO. 2525 Clybourn Chicago, Illinois

S-M-O-O-T-H VOLTAGE CONTROL for A.C. circuits

The Type "TH" Transtat is the new continuously variable auto-transformer regulator . . . the ideal voltage control for a.c. circuits. It offers high efficiency, good regulation, great flexibility and dependable construction at moderate cost. Standard types are available for controlling voltage to single-phase and polyphase loads rated 10 Kva. and smaller, 50 or 60 cycles, 115, 230 or 460 volts. May we send you bulletin 51-1 which contains complete data?

TRANSTAT VOLTAGE REGULATORS

AMERICAN TRANSFORMER CO.
178 Emmet St. Newark, N. J.

REGULATORS, AUTOMATIC, Oil Feed
Askania Regulator Co.
Atlas Valve Co.
Brown Inst. Co.
Cash Co.
D'Este Co.
Foster Engg. Co.
General Regulator Corp.
Hagan Corp.
Lammert & Mann Co.
Mason-Neilan Regulator
McAlear Mfg. Co.
McCorkle Co.
National Airoil Burner
Republic Flow Meters
Spence Engineering Co.
Taylor Inst. Cos.
United Cinephone Corp.
Vaughn-G. E. Witt Co.
Wilgus Manufacturing

REGULATORS, AUTOMATIC, Power Factor
Allis-Chalmers Mfg. Co.
Leeds & Northrup Co.
United Cinephone Corp.

REGULATORS, AUTOMATIC, Pressure (See Controllers, Automatic, Pressure)

REGULATORS, AUTOMATIC, Pump
Allen-Bradley Co.
Area Regulators, Inc.
Askania Regulator Co.
Atlas Valve Co.
Bailey Meter Co.
Belfield Co.
Boylston Co.
Brown Inst. Co.
Builders Iron Foundry
Cash Co.
Davis Reg. Co.
D'Este Co.
Fisher Governor Co.
Ford Reg. Valve Co.
Foster Engg. Co.
Furnas Electric Co.
General Regulator Corp.
Hagan Corp.
Hanlon-Waters, Inc.
Hydraulic Press Co.
Klipfel Mfg. Co.
Leslie Co.
Mason-Neilan Regulator
McAlear Mfg. Co.
Mercon Regulator Co.
Northern Equip. Co.
Penn Electric Switch
Republic Flow Meters
Water Level Controls Co.
Schade Valve Mfg. Co.
Spence Engineering Co.
Tagliabue Mfg. Co.
Vaughn-G. E. Witt Co.
Watts Regulator Co.
Wilgus Mfg. Co.

REGULATORS, AUTOMATIC, Refrigeration (See Controllers, Automatic, Refrigeration)

REGULATORS, AUTOMATIC, RKVA
Allis-Chalmers Mfg. Co.

REGULATORS, AUTOMATIC, Safety Fuel Shut-Off (See Valves, Automatic, Safety Fuel Shut-Off)

REGULATORS, AUTOMATIC, Speed (See Controllers, Automatic, Speed)

REGULATORS, AUTOMATIC, Steam (See Regulators, Automatic, Pressure)

REGULATORS, AUTOMATIC, Steam Pressure (See Regulators, Automatic, Pressure)

REGULATORS, AUTOMATIC, Synchronizing
Allis-Chalmers Mfg. Co.
Industrial Engr. Corp.
Magnetic Gauge Co.

REGULATORS, AUTOMATIC, Temperature (See Controllers, Automatic, Temperature)

REGULATORS, AUTOMATIC, Time (See Controllers, Automatic, Time)

REGULATORS, AUTOMATIC, Vacuum (See Controllers, Automatic, Vacuum)

REGULATORS, AUTOMATIC, Viscosity (See Controllers, Automatic, Viscosity)

REGULATORS, AUTOMATIC, Voltage
Allis-Chalmers Mfg. Co.
American Transformer
Amperite Corp.
Burlington Inst. Corp.
Clarostat Mfg. Co.
Eclipse Aviation
Ferris Inst. Corp.
Electronic Prod. Co.
General Elec. Co.
Ideal Commuto'r Dresser
International Resistance
Jones-Orme Co.
Luxtrol Co., Inc.
Miller Co., Bertrand F.
Raytheon Mfg. Co.
Roller-Smith Co.
Sola Electric Co.
United Cinephone Corp.
United Transformer Corp.
Ward Leonard Elec. Co.

REGULATORS, AUTOMATIC, Water Pressure (See Regulators, Automatic, Pressure)

REGULATORS, AUTOMATIC, Welding, Gas
Bastian-Blessing Co.
Dockson Co.
Victor Equipment Co.

REGULATORS, MANUAL (Non-Automatic)
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Bailey Meter Co.
Beck Bros.
Belfield Co.
Brown Inst. Co.
Cutler-Hammer, Inc.
Hanlon-Waters, Inc.
McAlear Mfg. Co.
National Airoil Burner
National Elec. Controller
Standard Elec. Prods.
Superior Electric Co.
Tagliabue Mfg. Co.
United Transformer Corp.
Ward Leonard Elec. Co.

RELAYS, Automatic
Allen-Bradley Co.
American Inst. Co.
American Automatic Elec.
Autocall Co.
Clare & Co.
Cutler-Hammer, Inc.
Eclipse Aviation
General Controls Co.
General Elec. Co.
Guardian Elec. Mfg. Co.
Hagan Corp.
Industrial Eng. Corp.
Kellogg Switchboard
Mercoid Corp.
Monitor Controller Co.
Paragon Electric Co.
Penn Electric Switch
Perfex Corp.
Struthers-Dunn
Ward Leonard Elec. Co.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

RELAYS, Capacity-Operated
Electronic Lab.
Luxtrol Co., Inc.

RELAYS, Circuit Control
Advance Electric Co.
Allen-Bradley Co.
American Automatic Elec.
American Inst. Co.
Autocall Co.
Automatic Switch Co.
Brown Inst. Co.
Clare & Co.
Electric Controller
Friez & Sons
General Elec. Co.

(Continued on next page)

TYPE 4357T controller with Type 4300 Wizard Pilot mounted integral with topwork. Note greater compactness of pilot assembly.

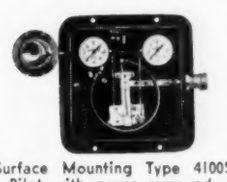
Use

FISHER WIZARD PILOT REGULATORS

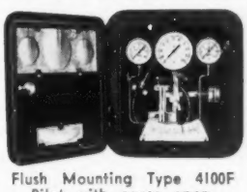
with throttling range adjustment

1. Throttling Range Adjustment —1% to 75% of Tube Range.
2. Vernier hand adjustment mechanism for pressure setting.
3. Larger and more sensitive Bourdon Tube.
4. Weather-proof integral gauge housings.
5. Gas-tight and weather-proof cases.
6. High pressure control connections and leads.
7. Easily changed from reverse to direct acting or vice-versa—without changing tube position.

Wizard Pilot Valves for Remote Control



Surface Mounting Type 4100S Pilot with cover removed.



Flush Mounting Type 4100F Pilot with cover open.

Pressure range from 2 to 10,000 lbs.

WRITE for FREE literature and prices

FISHER GOVERNOR COMPANY
1301 Fisher Bldg., Marshalltown, Iowa

VARITRAN CONTROLS

FOR CONTROLLING: Line Voltage . . . Electric furnaces . . . Motors . . . Lights . . . Breakdown testers . . . Motor calibrators . . . Soldering irons . . . Welders

VARITRAN UNITS *PROVIDE* smooth, efficient, continuously variable output from 0-130 Volts (115 V. units). Available from 230 Watts to 5 KW.

Write for Bulletin 18-1

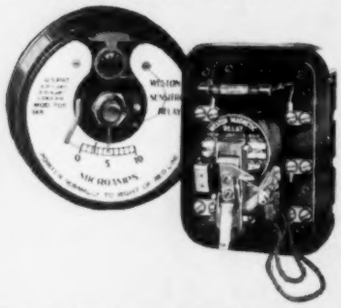
UNITED TRANSFORMER CORP.

Write: INDUSTRIAL DIV. • 150 VARICK ST. • NEW YORK, N. Y.
EXPORT DIV: 100 VARICK ST., NEW YORK, N. Y. CABLES: "ARLAB"

For addresses, see pages 56-64

SENSITIVE and POWER

RELAYS



A complete line of sensitive relays and contact making indicators . . . including the Sensitrol Relay which provides positive control at energy levels as low as 1 millivolt or 2 microamperes, handling 5 watts at 110 volts on magnetic contacts. Also Time Delay Relays and Power Relays for operation from sensitive relay contacts. Bulletins available. Weston Electrical Instrument Corporation, 591 Frelinghuysen Ave., Newark, New Jersey.

WESTON *Instruments*

AGASTAT

The Name for TIME-DELAY RELAY

An instantaneous recycling unit giving a delay interval ranging from a fraction of a second to several minutes, for use in electrical apparatus and equipment.

Positive, snap-action contacts, normally open, normally closed, or both. Single or double-pole. Offers a diversity of timing effects by different circuit combinations. Simple field adjustment. Unaffected by dust, temperature, humidity or voltage fluctuations.

Write Today for Bulletin N-4.

AMERICAN GAS ACCUMULATOR CO.

Electrical Division

ELIZABETH • NEW JERSEY

RELAYS, Circuit Control (Cont'd)
Guardian Elec. Mfg. Co.
H-B Inst. Co., Inc.
Kellogg Switchboard
Leach Relay Co.
Lumenite Elec. Co.
Miller Co., Bertrand F.
Monitor Controller Co.
Paragon Electric Co.
Sigma Instruments, Inc.
Standard Elec. Prods.
Struthers-Dunn
United Cinephone Corp.
Ward Leonard Elec. Co.
Western Electro-Mech.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

RELAYS, Continuous Current
Allen-Bradley Co.
American Automatic Elec.
American Inst. Co.
Autocall Co.
Clare & Co.
General Elec. Co.
Guardian Elec. Mfg. Co.
H-B Inst. Co., Inc.
Kellogg Switchboard
Paragon Electric Co.
Struthers-Dunn
Ward Leonard Elec. Co.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

RELAYS, Control
Allen-Bradley Co.
Advance Electric Co.
American Automatic Elec.
American Inst. Co.
Autocall Co.
Automatic Switch Co.
Betts & Betts
Brown Inst. Co.
Clare & Co.
Cutler-Hammer, Inc.
Electric Controller
Friez & Sons
General Controls Co.
General Elec. Co.
Guardian Elec. Mfg. Co.
Hagan Corp.
H-B Inst. Co., Inc.
Industrial Eng. Corp.
Kellogg Switchboard
Miller Co., Bertrand F.
Monitor Controller Co.
Perfex Corp.
Precision Therm. & Inst.
Roller-Smith Co.
Standard Elect. Prods.
Struthers-Dunn
United Cinephone Corp.
Ward Leonard Elec. Co.
Western Electro-Mech.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

RELAYS, Demand Totalizing
Autocall Co.
General Elec. Co.
Hagan Corp.
Therm-Electric Meters Co.
United Cinephone Corp.
Westinghouse Elec. & Mfg.

RELAYS, Electromagnetic
Advance Electric Co.
Allen-Bradley Co.
American Automatic Elec.
American Inst. Co.
Autocall Co.
Automatic Switch Co.
Bunnell & Co.
Eby, Inc.
Clare & Co.
Cutler-Hammer, Inc.
Friez & Sons
General Elec. Co.
G-M Labs.
Guardian Elec. Mfg. Co.
H-B Inst. Co.
Industrial Eng. Corp.
Kellogg Switchboard
Kurman Electric Co.

RELAY, Electromagnetic (Cont'd)
Leach Relay Co.
Miller Co., Bertrand F.
Monitor Controller Co.
Penn Electric Switch Co.
Perfex Corp.
Phila. Thermometer Co.
Precision Therm. & Inst.
Sigma Instruments, Inc.
Standard Elect. Prods.
Struthers-Dunn
United Cinephone Corp.
Ward Leonard Elec. Co.
Western Electro-Mech.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.
White-Rodgers Electric
Zenith Electric Co.

RELAYS, Frequency
Autocall Co.
Clare & Co., C. P.
Cutler-Hammer, Inc.
Esterline-Angus Co.
Hickok Electrical Inst.
United Cinephone Corp.
Ward Leonard Electric Co.

RELAYS, Galvanometer
Autocall Co.
Eby, Inc., Hugh H.
G-M Laboratories, Inc.
Rubicon Co.
Tagliabue Mfg. Co., C. J.

RELAYS, Heavy Duty
Allen-Bradley Co.
American Automatic Elec
American Inst. Co.
Autocall Co.
Automatic Switch Co.
Cutler-Hammer, Inc.
General Elec. Co.
H-B Inst. Co., Inc.
Miller Co., Bertrand F.
Monitor Controller Co.
Penn Electric Switch
Philadelphia Thermometer
Ward Leonard Elec. Co.
Westinghouse Elec. & Mfg.
Zenith Electric Co.

RELAYS, Instrument Controlled
American Automatic Elec.
American Inst. Co.
Autocall Co.
Brown Inst. Co.
Clare & Co.
Cramer & Co., Inc.
Friez & Sons
General Elec. Co.
Guardian Elec. Mfg. Co.
H-B Inst. Co., Inc.
Kurman Electric Co.
Perfex Corp.
Phila. Thermometer Co.
Precision Therm. & Inst.
Roller-Smith Co.
Struthers-Dunn
Tagliabue Mfg. Co.
Triplett Electrical Inst.
United Cinephone Corp.
Ward Leonard Elec. Co.
Weston Elec. Inst. Corp.

RELAYS, Light Sensitive (See Photoelectric below)

RELAYS, Magnetic (See Relays, Electro-Magnet)

RELAYS, Mercury
American Automatic Elec.
American Inst. Co.
Autocall Co.
Continental Elec. Co.
H-B Elec. Co., Inc.
H-B Inst. Co., Inc.
Loewenberg, F.
Precision Therm. & Inst.
Weston Elec. Inst. Corp.

RELAYS, Mercury Tube
American Inst. Co.
Autocall Co.
Brown Inst. Co.
Clare & Co.
General Control Co.

RELAYS, Mercury Tube (Cont'd)
G-M Labs.
Guardian Elec. Mfg. Co.
H-B Elec. Co., Inc.
H-B Inst. Co., Inc.
Loewenberg, F.
Phila. Thermometer Co.
Precision Therm. & Inst.
Steele, Erick F.
Struthers-Dunn
Ward Leonard Elec. Co.
Weston Elec. Inst. Corp.

RELAYS, Motor Driven Time Delay
Advance Electric Co.
American Inst. Co.
Betts & Betts
Cramer & Co., Inc.
Southw'n Electronics Labs
Struthers-Dunn
Friez & Sons
General Elec. Co.
Industrial Eng. Corp.
Monitor Controller Co.
Paragon Electric Co.
Ward Leonard Elec. Co.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.
Zenith Electric Co.

RELAYS, Movable Coil A.C.
Esterline-Angus Co.
Etna Elec. Works
General Elec. Co.
Weston Elec. Inst. Corp.

RELAYS, Overload
Allen-Bradley Co.
Autocall Co.
Bunnell & Co.
Cutler-Hammer, Inc.
Edison Electrical Controls
Electric Controller
General Elec. Co.
Guardian Elec. Mfg. Co.
Leach Relay Co.
Penn Electric Switch
Roller-Smith Co.
Standard Elect. Prods.
Struthers-Dunn
Ward Leonard Elec. Co.
Westinghouse Elec. & Mfg.

RELAYS, Permanent Magnet Movable Coil
Bunnell & Co.
Esterline-Angus Co.
Etna Elec. Works
General Elec. Co.
Triplett Electrical Inst.
Weston Elec. Inst. Corp.

RELAYS, Photoelectric
Advance Electric Co.
American Inst. Co.
Eby, Inc.
Clare & Co.
Continental Elec. Co.
Cutler-Hammer, Inc.
Dickson Co.
Electronic Lab.
Electronic Prod. Co.
Ess Instrument Co.
Etna Elec. Works
General Controls Co.
General Elec. Co.
G-M Labs.
Leach Relay Co.
Lipman Engg. Co.
Lumenite Elec. Co.
Luxtrol Co., Inc.
Photobell Corp.
Photoswitch, Inc.
Precision Therm. & Inst.
Rehtron Corp.
Sigma Instruments, Inc.
Tagliabua Mfg. Co.
United Cinephone Corp.
Ward Leonard Elec. Co.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

RELAYS, Polarized
American Automatic Elec.
Autocall Co.
Edison Electrical Controls
L. A. B. Corp.
Miller Co., Bertrand F.
Precision Therm. & Inst.
Struthers-Dunn
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

RELAYS, Power
American Automatic Elec.
American Inst. Co.
Automatic Switch Co.
Esterline-Angus Co.
General Controls Co.
General Elec. Co.
Hagan Corp.
Struthers-Dunn
Ward Leonard Elec. Co.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

RELAYS, Power Factor
Esterline-Angus Co.
L. A. B. Corp.
Westinghouse Elec. & Mfg.

RELAYS, Resistance, D-c.
Advance Electric Co.
Autocall Co
Automatic Electric Co.
Bunnell & Co.
Clare & Co., C. P.
Cutler-Hammer, Inc.
Dunn, Inc., Struthers
Leach Relay Co.
Standard Elect. Products

RELAYS, Stepping
Autocall Co.
Automatic Electric Co.
Dunn, Inc., Struthers
G-M Laboratories, Inc.
Roller-Smith Co.

RELAYS, Telephone Auxiliary Ringing
Advance Electric Co.
American Automatic Elec
Autocall Co.
Clare & Co.
Kellogg Switchboard
Kurman Electric Co.
Leach Relay Co.
Standard Elect. Prods.
Struthers-Dunn
Western Electro-Mech.

RELAYS, Temperature
Autocall Co.
Clare & Co., C. P.
Dunn, Inc., Struthers
Edison Electrical Controls
Friez & Sons
Gleason-Avery, Inc.
G-M Laboratories, Inc.
Leach Relay Co.
Photobell Corp.
Spencer Thermostat Co.
Tagliabue Mfg. Co., C. J.
United Cinephone Corp.
Weston Electrical Inst.

RELAYS, Thermal Time Delay
Advance Electric Co.
Allen-Bradley Co.
American Automatic Elec
Am. Gas Accumulator
American Inst. Co.
Autocall Co.
Automatic Temp. Control
Betts & Betts
Cramer & Co., Inc.
Cutler-Hammer, Inc.
Eagle Signal Corp.
Edison Electrical Controls
Electric Controller
Electronic Prod. Co.
General Elec. Co.
Guardian Elec. Mfg. Co.
Industrial Eng. Corp.
Loewenberg, F.
Luxtrol Co., Inc.
Magnetic Gauge Co.
Paragon Electric Co.
Perfex Corp.
Photobell Corp.
Precision Therm. & Inst.
Preferred Utilities Mfg.
Spencer Thermostat Co.
Standard Elect. Prods.
Struthers-Dunn
Ward Leonard Elec. Co.
Weston Elec. Inst. Corp.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.
White-Rodgers Electric
Zenith Electric Co.

RELAYS, Time Delay (See Relays, Thermal Time Delay)

RELAYS, Transformer (Low Voltage)
Allen-Bradley Co.
Eclipse Aviation
Friez & Sons
General Controls Co.
Gleason-Avery, Inc.
Guardian Elec. Mfg. Co.
H-B Inst. Co., Inc.
Industrial Eng. Corp.
Miller Co., Bertrand F.
Paragon Electric Co.
Penn Electric Switch
Perfex Corp.
Sigma Instruments, Inc.
Struthers-Dunn
Westinghouse Elec. & Mfg.
White-Rodgers Electric

RELAYS, Vacuum Contact
American Automatic Elec.
American Inst. Co.
Edison Electrical Controls

RELAYS, Vacuum Tube
American Inst. Co.
Continental Elec. Co.
Eby, Inc.
Electro-Medical Lab.
Electronic Prod. Co.
General Controls Co.
General Elec. Co.
G-M Labs.
L. A. B. Corp.
Lumenite Elec. Co.
Luxtrol Co., Inc.
Photobell Corp.
Precision Therm. & Inst.
RCA Manufacturing Co.
Sargent & Co.
Sigma Instruments
Standard Elect. Prods.
Struthers-Dunn
Tagliabue Mfg. Co.
United Cinephone Corp.

RELAYS, Voltage
Advance Electric Co.
Allen-Bradley Co.
Autocall Co.
Automatic Switch Co.
Clare & Co., C. P.
Cutler-Hammer, Inc.
Dunn, Inc., Struthers
Eby, Inc., Hugh H.
Esterline-Angus Co.
Ferranti Electric, Inc.
Hart Manufacturing Co.
Hathaway Inst. Co.
Leach Relay Co.
Photobell Corp.
Reliance Instrument Co.
Roller-Smith Co.
Standard Elect. Products
Ward Leonard Electric Co.
Triplett Electrical Inst.
Weston Electrical Inst.

(Continued on page 38)

TIME DELAY RELAYS

- **TIME DELAY RELAYS**—Thermostatically controlled or motor driven; for any voltage, any load, any application.
- **SINGLE OR MULTIPLE CONTACT CYCLE TIMERS**—Continuous, repeat or instantaneous reset types. Accurate timing adjustments of individual circuits and of complete cycle.

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For addresses, see pages 56-64

RELAYS WITH PEP

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MANUFACTURERS OF H B ELECTRICAL DEVICES

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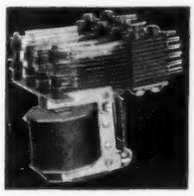
For AC or DC Operation

Relays, Solenoids and Stepping Switches illustrated below show just a few of numerous types of electrical control units engineered and manufactured by Guardian Electric. Built by *specialists* in COMPACT and highly sensitive electrical controls, Guardian units possess unusual responsiveness and precision of action. The entire line has been designed and developed for maximum control in minimum space. Guardian Electric controls can be obtained for operation on any specified voltage to 220 DC, 440 AC; on any current from .5 milliampere to 30 amperes; contact capacities to 1600 watts.

ALTERNATING CURRENT RELAYS



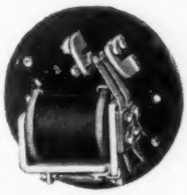
Series 30

Series 30 (left) Supplied in three types of mountings, voltage range .1 to 440 volts, contact capacity 42 contacts. Size 2¾x1½x2½.

Series 110 (right) Compact, economical, widely used unit. Four pole, double throw contact capacity. 220 volt limit. Size 2¾x⅞x1 15/16".

Series 110

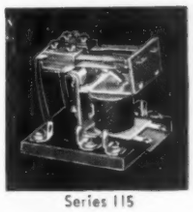
DIRECT CURRENT RELAYS



Series 5

Series 5 (left) Current draw as low as .008 watts—furnished completely enclosed — contact limit, double pole, double throw. Size 3¼x3¼x2"

Series 115 (right) Four pole, double throw contact capacity, rapid change over of contacts, full floating, permanently locked armature, economical of space and cost.



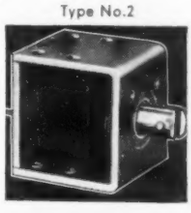
Series 115

S-T-E-P-P-I-N-G RELAYS

Versatile, advanced designs, simple in principle. New applications for these units are appearing constantly giving circuit control hitherto thought impossible. Rigidity of construction guarantees long life. Innumerable variations available.

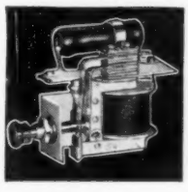
Type-R Stepping Relay

Type No.2



SOLENOIDS— AC; DC

Type No. 2. Efficient—powerful—compact. For electro-mechanical operations involving remote control of mechanical motions such as electric counting, valve control and operation, faulty material ejector, automatic brake, electric racheting, etc. 1½x1½x1⅝.



Overload Relays

Positive, precise protection against current surges, continuous overload. Manual reset. Size 4x2½x3½.

RF Relays Type R-100

Single or double pole, single or double throw, relay with coil wound for 110 volt or 6 volt—60 cycle AC. For high frequency applications.

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Davis Reg. Co.
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Electrimatic Corp.
Electronic Lab.
Elsbert Mfg. Co.
Foxboro Co.
General Elec. Co.
Hanlon-Waters, Inc.
Hart Mfg. Co.
Hays Corp.
H-B Inst. Co., Inc.
Illinois Eng. Co.
International Filter Co.
Kollsman Inst. Co.
Kurman Electric Co.
Luxtrol Co., Inc.
Mason-Neilan Regulator
Perfex Corp.
Photobell Corp.
Powers Regulator Co.
RCA Manufacturing Co.
Republic Flow Meters
Scientific Inst. Co.
Tagliabue Mfg. Co.
United Cinephone Corp.
Zenith Electric Co.

REMOTE-METERING EQUIPMENT, ELECTRICAL
Andrew, Victor J.
Bristol Co.
Brown Inst. Co.
Builders Iron Foundry
Elec. Indicator Corp.
Elec. Tachometer Corp.
Esterline-Angus Co.
Foxboro Co.
General Elec. Co.
W. & L. E. Gurley
Kellogg Switchboard
Kurman Electric Co.
L. A. B. Corp.
Leeds & Northrup Co.
Mason-Neilan Regulator
Moisture Register Co.
Morey & Jones, Ltd.
Republic Flow Meters
Tagliabue Mfg. Co.
Therm-Electric Meters
Westinghouse Elec. & Mfg.

REMOTE-METERING EQUIPMENT, HYDRAULIC
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Builders Iron Foundry
International Filter Co.
Leupold, Volpel & Co.
Westinghouse Elec. & Mfg.

REMOTE-METERING EQUIPMENT, PNEUMATIC
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Bristol Co.
Brown Inst. Co.
Foxboro Co.
Mason-Neilan Regulator

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Precision Resistor Co.

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Clarostat Mfg. Co.
Cutler-Hammer, Inc.
Daven Co.
General Radio Co.
Instrument Resistors,
International Resistance
Ohmite Mfg. Co.
Precision Resistor Co.
Sensitive Research Inst.
Shallcross Mfg. Co.

RESISTORS, Adjustable
Ward Leonard Electric Co.

RESISTORS CARBON COMPRESSION
Allen Bradley Co.
Beck Bros.
International Resistance
Le Carbone Co., Inc.
Nat'l Carbon Co., Inc.
Ohio Carbon Co.
O. S. Peters
Speer Carbon Co.
Welch Scientific Co.
Eastern Specialty Co.
Hardwick, Hindle, Inc.
International Resistance
Precision Resistor Co.

RESISTORS, High Frequency
Beck Bros.
Daven Co.
General Radio Co.
Hardwick, Hindle, Inc.
Instrument Resistors, Inc.
International Resistance
Leeds & Northrup Co.
Microvolts, Inc.
Ohmite Mfg. Co.
Shallcross Mfg Co.
Ward Leonard Electric Co.

RESISTORS, High Voltage
Beck Bros.
Clarostat Mfg. Co.
Hardwick, Hindle, Inc.
Instrument Resistors, Inc.
International Resistance
J B L Instrument Co.
Ohmite Mfg. Co.
Shallcross Mfg. Co.
Ward Leonard Electric Co.

RESISTORS, Manganin
Beck Bros.
Daven Co.
General Radio Co.
Gray Instrument Co.
Hardwick, Hindle, Inc.
Instrument Resistors, Inc.
Leeds & Northrup Co.
Rubicon Co.
Shallcross Mfg. Co.

RESISTORS, Molded
Allen-Bradley Co.
Beck Bros.
Clarostat Mfg. Co.
International Resistance
Muter Co.
Triplett Electrical Inst.

RESISTORS, Standard
(See Standards, Resistance)

RESISTORS, Variable
Allen-Bradley Co.
Beck Bros.
Clarostat Mfg. Co.
Cutler-Hammer, Inc.
General Radio Co.
Gray Instrument Co.
Hardwick, Hindle, Inc.
Instrument Resistors, Inc.
International Resistance
Leeds & Northrup Co.
National Electric Control.
Ohmite Mfg. Co.
Rex Rheostat Co.
Rubicon Co.

RESISTORS, Wire Wound
Beck Bros.
Clarostat Mfg. Co.
Cutler-Hammer, Inc.
Daven Co.
General Radio Co.
Gray Instrument Co.
Hardwick, Hindle, Inc.
Instrument Resistors, Inc.
International Resistance
Leeds & Northrup Co.
Muter Co.
National Electric Control.
Ohmite Mfg. Co.
Rex Rheostat Co.
Rubicon Co.
Shallcross Mfg. Co.
Triplett Electrical Inst.
Ward Leonard Electric Co.

RHEOSTATS, Battery Charging
Allen-Bradley Co.
Allen Elec. & Equip. Co.
Beck Bros.
Cutler-Hammer, Inc.
Hardwick, Hindle, Inc.
International Resistance
National Elec. Controller
Ohmite Mfg. Co.
Rex Rheostat Co.
Schaefer Bros. Co.
Ward Leonard Elec. Co.

RHEOSTATS, Laboratory
Allen-Bradley Co.
American Inst. Co.
Beck Bros.
Biddle Co., Jas. G.
Central Scientific Co.
Chicago Apparatus Co.
Eastern Specialty Co.
General Radio Co.
G-M Labs.
Hardwick, Hindle, Inc.
National Elec. Controller
Ohmite Mfg. Co.
Rex Rheostat Co.
Rubicon Co.
Schaefer Bros. Co.
Ward Leonard Elec. Co.

RHEOSTATS, Meter Testing
Allen-Bradley Co.
Beck Bros.
Biddle Co., Jas. G. N4
Eastern Specialty Co.
Hardwick, Hindle, Inc.
International Resistance
Leeds & Northrup
National Elec. Controller
Ward Leonard Elec. Co.

RHEOSTATS, Slide Wire
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Biddle Co., Jas. G.
Central Scientific Co.
Chicago Apparatus Co.
General Radio Co.
Hardwick, Hindle, Inc.
G-M Labs.
Leeds & Northrup
National Elec. Controller
Rex Rheostat Co.
Rubicon Co.
Shallcross Mfg. Co.
Ward Leonard Elec. Co.

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Impact Register Co.
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Impact Register Co.
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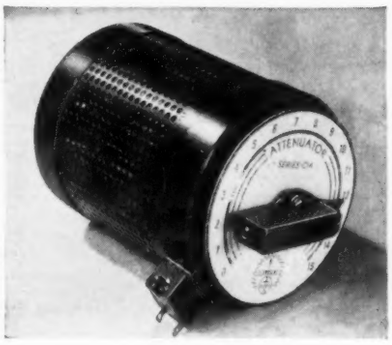

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545	100	1	10×10	13.50
546	1,000	1	10×100	13.50
547	10,000	1	10×1,000	13.50
548	100,000	1	10×10,000	16.50
549	1,000,000	1	10×100,000	27.50
550	10,000,000	1	10×1,000,000	42.50

Send for Bulletin No. 835-HN

SHALLCROSS MFG. COMPANY
Electrical Measuring Instruments and Accurate Resistors
COLLINGDALE, PA.

RULES, Adjustable Curve
(See Drawing Instruments)

RULES, Aluminum
Keuffel & Esser Co.
Lufkin Rule Co.
Warren-Knight Co.

RULES, Brass
Bliss & Co.
Lufkin Rule Co.
Mico Instrument Co.
Starrett Co.
Warren-Knight Co.

RULES, Caliper
Glogau & Co.
Lufkin Rule Co.
Millers Falls Co.
Starrett Co.
Union Tool Co.
Warren-Knight Co.

RULES, Drafting Room
(See Drawing Instruments)

RULES, Folding
Bliss & Co.
Dietzen Co.
Keuffel & Esser Co.
Lufkin Rule Co.
Post Co., Frederick
Speidel & Co.
Starrett Co.
Warren-Knight Co.
Weber Co.

RULES, Glass
Fish-Schurman Co.
Glass Engraving Co.
Mico Instrument Co.

RULES, Parallel
Bliss & Co.
Dietzen Co.
Hamilton Mfg. Co.
Keuffel & Esser Co.
Negus, T. S. & J. D.
Speidel & Co.
Warren-Knight Co.
White Co., Inc.
Weber Co.

RULES, Precision Standard
Gaertner Scientific Corp.

RULES, Shrinkage
Keuffel & Esser Co.
Lufkin Rule Co.
Speidel & Co.
Starrett Co.
Warren-Knight Co.
Weber Co.

RULES, Slide (See Drawing Instruments)

RULES, Slide, Psychrometric
Friez & Sons

RULES, Steel
Kern Co.
Keuffel & Esser Co.
Lufkin Rule Co.
Mico Instrument Co.
Millers Falls Co.
Scherr Co., Inc.
Speidel & Co.
Starrett Co.
Union Tool Co.
Warren-Knight Co.
Weber Co.

RULES, Wood
Henschel & Co.
Keuffel & Esser Co.
Lufkin Rule Co.
Post Co., Frederick
Speidel & Co.
Warren-Knight Co.
Weber Co.

RUNNING TIME TOTALIZERS
Cramer & Co., Inc.
Elec. Tachometer Corp.
Jaeger Watch Co.
Production Instrument

SACCHARIMETERS
Akatos, Inc.
Berg Mfg. Co.
Central Scientific Co.
Eimer & Amend
Moeller Instrument Co.
Rieker Inst. Co.
Sargent & Co.
Trerice Co.

SACCHAROMETERS
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Central Scientific Co.
Eimer & Amend
Fleischhauer & Son
G. M. Mfg. Co., Inc.
H.B Inst. Co.
Kimble Glass Co.
Moeller Instrument Co.
Precision Therm. & Inst.
Rascher & Betzold
Rieker Inst. Co.
Ruehfel Co.
Schultheis Corp., E. W.
Scientific Inst. Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Wagner & Son

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Berg Mfg. Co.
Central Scientific Co.
Eimer & Amend
Engineering Labs., Inc.
Fleischhauer & Son
G. M. Mfg. Co., Inc.
H-B Inst. Co.
Leeds & Northrup Co.
McNab of Bridgeport
Precision Therm. & Inst.

SALINITY INDICATORS
(Cont'd)
Rascher & Betzold
Ruehfel Co.
Schultheis Corp.
Scientific Inst. Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Trerice Co.

SALINOMETERS (See Salinity Indicators)

SAMPLER, Boiler Water
Natl. Aluminate Corp.

SAMPLERS Oil
Braun Corp.
Central Scientific Co.
Pgh. Equitable Meter
Refinery Supply Co.
Scientific Glass Apparatus
Tagliabue Mfg. Co.

SAMPLERS, Oil Bottom-hole
Ruska & Co., Inc.

SAMPLERS, Sewage
Builders Iron Foundry
Central Scientific Co.
International Filter Co.
Scientific Glass Apparatus

SAMPLERS, Silt
Central Scientific Co.

SCALES (See also object of measurement)

SCALES, Antimony Test
Howe Scale Co.
Seederer-Kohlbusch, Inc.
Troemner, Henry

SCALES, Automatic
Automatic Scale Co.
Buffalo Scale Co.
Chatillon & Sons
Exact Weight Scale
Fairbanks, Morse & Co.
Gump Co.
Howe Scale Co.
International Bus. Mach.
Jacobs Bros. Co., Inc.
Kron Co.
Merrick Scale Mfg. Co.
Richardson Scale Co.
Schaffer Poidometer Co.
Streeter-Amet Co.
Toledo Scale Co.
Triangle Package Mach.
Triner Sales Co.

SCALES, Bag Filling
Automatic Scale Co.
Exact Weight Scale Co.
Fairbanks, Moore & Co.
Gump Co.
Jacobs Bros. Co.
Kron Co
Richardson Scale Co.
Syntron Company
Toledo Scale Co.
Triangle Package Mach.

SCALES, Basis Weight
Amthor Testing Inst. Co.
Becker, Inc., Christian
Buffalo Scale Co.
Exact Scale Co.
Howe Scale Co.
Kron Co.
Seederer-Kohlbusch
Thwing-Albert Instrument
Toledo Scale Co.
Torsion Balance Co.
Triner Sales Co.

SCALES, Bulk Weighing
Atlas Car & Mfg. Co.
Becker, Inc., Christian
Buffalo Scale Co.
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Howe Scale Co.
Jacobs Bros. Co.
Kron Co.
Merrick Scale Mfg.
Richardson Scale Co.
Schaffer Poidometer Co.
Streeter-Amet Co.
Toledo Scale Co.
Torsion Balance Co.
Triangle Package Mach.
Triner Sales Co.
Troemner, Henry

SCALE, Cement Batching
Buffalo Scale Co.
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Howe Scale Co.
Kron Co.
Richardson Scale Co.
Streeter-Amet Co.
Toledo Scale Co.
Triner Sales Co.

SCALES, Checking
Becker, Inc., Christian
Buffalo Scale Co.
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Jacobs Bros. Co., Inc.
Kron Co.
Merrick Scale Mfg. Co.
Richardson Scale Co.
Toledo Scale Co.
Torsion Balance Co.
Triner Sales Co.

SCALES, Classifying
Exact Weight Scale Co.
Jacobs Bros. Co., Inc.
Kron Co.
Toledo Scale Co.
Triner Sales Co.

SCALES, Computing
Amthor Testing Inst.
Exact Weight Scale
International Bus. Mach.
Jacobs Bros., Inc.
Toledo Scale Co.
Triner Sales Co.

SCALES, Continuous Weighing
Buffalo Scale Co.
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Gump Co.
Jacobs Bros. Co.
Jeffrey Mfg. Co.
Kron Co.
Merrick Scale Mfg. Co.
Richardson Scale Co.
Schaffer Poidometer Co.
Streeter-Amet Co.
Syntron Company
Toledo Scale Co.
Triangle Package Mach.
United Cinephone Corp.

SCALES, Conveyor
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Howe Scale Co.
International Bus. Mach.
Kron Co.
Merrick Scale Mfg. Co.
Richardson Scale Co.
Schaffer Poidometer Co.
Streeter-Amet Co.
Toledo Scale Co.

SCALES Counting
Amthor Testing Inst. Co.
Buffalo Scale Co.
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Howe Scale Co.
International Bus. Mach.
Jacobs Bros. Co.
Kron Co.
Seederer-Kohlbusch
Toledo Scale Co.
Triner Sales Co.
United Cinephone Corp.

SCALES, Crane
Buffalo Scale Co.
Chatillon & Sons
Fairbanks, Morse & Co.
Howe Scale Co.
Kron Co.

SCALES, Dairy
Becker, Inc., Christian
Buffalo Scale Co.
Central Scientific Co.
Chatillon & Sons
Exact Weight Scale Co.
Fairbanks Morse & Co.
Howe Scale Co.
Humboldt Mfg. Co.
International Bus. Mach.
Jacobs Bros. Co.
Kron Co.
Streeter-Amet Co.
Toledo Scale Co.
Torsion Balance Co.
Triner Sales Co.
Troemner, Henry

SCALES, Differential
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Jacobs Bros. Co., Inc.
Kron Co.
Thwing-Albert Instrument

SCALES, Drawing (See Drawing Instruments)

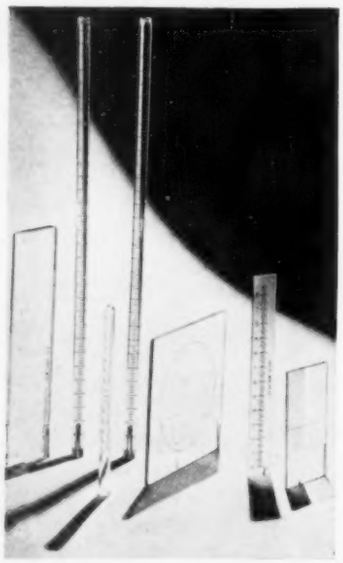
SCALES, Dump
Buffalo Scale Co.
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Howe Scale Co.
Kron Co.
Toledo Scale Co.

SCALES, Dynamometer
Central Scientific Co.
Chatillon & Sons
Dillon & Co.
Exact Weight Scale
Fairbanks, Morse & Co.
Howe Scale Co.
Kron Co.
Martin Decker Corp.
Seederer-Kohlbusch, Inc.
Toledo Scale Co.

SCALES, Estimating
Exact Weight Scale Co.
Jacobs Bros. Co
Seederer-Kohlbusch, Inc.
Troemner, Henry

SCALES, Grain & Seed Testing
Amthor Testing Inst. Co.
Automatic Scale Co.
Becker, Inc., Christian
Buffalo Scale Co.
Central Scientific Co.
Chatillon & Sons
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Fisher Scientific Co.
Gump Co.
Howe Scale Co.
Jacobs Bros. Co.
Kron Co.
Newark Scale Works
Richardson Scale Co.
Streeter-Amet Co.
Toledo Scale Co.
Torsion Balance Co.
Triangle Package Mach.
Triner Sales Co.
Troemner, Henry

SCALES, Hopper
Atlas Car & Mfg. Co.
Buffalo Scale Co.
Chatillon & Sons
Exact Weight Scale
Fairbanks, Morse & Co.
Gump Co.
Howe Scale Co.
Jacobs Bros. Co.
Kron Co.



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For addresses, see pages 56-64

SCALES, HOPPER (Cont'd)
Richardson Scale Co.
Streeter-Amet Co.
Toledo Scale Co.

SCALES, Laboratory
Becker, Inc., Christian
Buffalo Scale Co.
Central Scientific Co.
Chatillon & Sons
Chicago Apparatus Co.
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Fisher Scientific Co.
Howe Scale Co.
Humboldt Mfg. Co.
International Bus. Mach.
Jacobs Bros. Co.
Microchemical Service
Newark Scale Works
Seederer-Kohlbusch, Inc.
Toledo Scale Co.
Torsion Balance Co.
Troemner, Henry

SCALES, Larry Car
Atlas Car & Mfg. Co.
Buffalo Scale Co.
Fairbanks, Morse & Co.
Howe Scale Co.
Kron Co.
Richardson Scale Co.
Streeter-Amet Co.
Toledo Scale Co.

SCALES, Liquid
Jacobs Bros. Co., Inc.
Richardson Scale Co.

SCALES, Loss of Weight
Becker, Inc., Christian
Buffalo Scale Co.
Exact Weight Scale Co.
Jacobs Bros. Co.
Kron Co.
Seederer-Kohlbusch, Inc.
Streeter-Amet Co.
Toledo Scale Co.
Torsion Balance Co.

SCALES, Measuring
Automatic Scale Co.
Howe Scale Co.
Kron Co.
Richardson Scale Co.
Triner Sales Co.

SCALES, Over & Under
Becker, Inc., Christian
Buffalo Scale Co.
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Howe Scale Co.
International Bus. Mach.
Jacobs Bros. Co.
Moisture Register Co.
Streeter-Amet Co.
Toledo Scale Co.
Torsion Balance Co.
Triner Sales Co.
Troemner, Henry

SCALES, Packaging
Automatic Scale Co.
Becker, Inc., Christian
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Gump Co.
Howe Scale Co.
Kron Co.
International Bus. Mach.
Jacobs Bros. Co.
Pneumatic Scale Corp.
Richardson Scale Co.
Toledo Scale Co.
Torsion Balance Co.
Triangle Package Mach.
Triner Sales Co.
Troemner, Henry

SCALES, Platform
Becker, Inc., Christian
Buffalo Scale Co.
Chatillon & Sons
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Gump Co.
Howe Scale Co.
Humboldt Mfg. Co.
International Bus. Mach.
Knowles Scale Works
Kron Co.
Streeter-Amet Co.
Toledo Scale Co.
Torsion Balance Co.
Triner Sales Co.

SCALES, Portable
Black & Decker
Buffalo Scale Co.
Central Scientific Co.
Chatillon & Sons
Exact Weight Scale
Fairbanks, Morse & Co.
Gump Co.
Howe Scale Co.
International Bus. Mach.
Jacobs Bros. Co.
Knowles Scale Works
Kron Co.
Richardson Scale Co.
Toledo Scale Co.
Triner Sales Co.

SCALES, Predetermined Weight
Becker, Inc., Christian
Buffalo Scale Co.
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Gump Co.
Howe Scale Co.
International Bus. Mach.
Jacobs Bros. Co.
Merrick Scale Mfg. Co.
Richardson Scale Co.
Schaffer Poidometer Co.
Seederer-Kohlbusch, Inc.
Streeter-Amet Co.
Toledo Scale Co.
Torsion Balance Co.
Triner Sales Co.

SCALES, Recording
Buffalo Scale Co.
Fairbanks, Morse & Co.
Howe Scale Co.
Kron Co.
Merrick Scale Mfg. Co.
Richardson Scale Co.
Streeter-Amet Co.
Toledo Scale Co.
Wallace & Tiernan

SCALES, Remote Indicating
Toledo Scale Co.

SCALES, Rolling Mill
Buffalo Scale Co.
Fairbanks, Morse & Co.
Howe Scale Co.
Kron Co.
Streeter-Amet Co.
Toledo Scale Co.

SCALES, Sacking (See Scales, Bag filling)

SCALES, Selecting
Exact Weight Scale
Toledo Scale Co.
United Cinephone Corp.

SCALES, Solder Test
Central Scientific Co.
Exact Weight Scale
Seederer-Kohlbusch, Inc.
Troemner, Henry

SCALES, Steel
Exact Weight Scale
Fairbanks, Morse & Co.
Howe Scale Co.
Kron Co.
Lufkin Rule Co.
Streeter-Amet Co.
Toledo Scale Co.

SCALES, Testing
Becker, Inc., Christian
Buffalo Scale Co.
Exact Weight Scale
Gump Co.
Howe Scale Co.
Humboldt Mfg. Co.
Jacobs Bros. Co.
Kron Co.
Newark Scale Works
Toledo Scale Co.
Torsion Balance Co.

SCALES, Textile
Becker, Inc., Christian
Buffalo Scale Co.
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Howe Scale Co.
International Bus. Mach.
Kron Co.
Saxl Instrument Co.
Seederer-Kohlbusch, Inc.
Streeter-Amet Co.
Suter, Alfred
Toledo Scale Co.
Torsion Balance Co.
Triner Sales Co.

SCALES, Track
Buffalo Scale Co.
Fairbanks, Morse & Co.
Howe Scale Co.
Kron Co.
Streeter-Amet Co.
Toledo Scale Co.

SCALES, Truck
Black & Becker
Buffalo Scale Co.
Exact Weight Scale Co.
Fairbanks, Morse & Co.
Streeter-Amet Co.
Toledo Scale Co.

SCALES, Water Meter
Altender & Sons
Exact Weight Scale
Fairbanks, Morse & Co.
Jacobs Bros. Co.
Kron Co.
Toledo Scale Co.

SCALES, Yardage
Amthor Testing Inst.
Brown & Sharpe
Buffalo Scale Co.
Exact Weight Scale
Fairbanks, Morse & Co.
Howe Scale Co.
International Bus. Mach.
Kron Co.
Toledo Scale Co.

SCREENS, Solar Projecting
Fecker, J. W.

SCREENS, X-Ray Fluoroscopic
General Electric X-Ray
Kelley-Koett Mfg. Co.
Patterson Screen Co.
Westinghouse X-Ray Co.

SCREENS, X-Ray Intensifying (See Screens X-Ray Fluoroscopic)

SEED SIEVE SETS
Ballauf Mfg. Co.

SEGER CONES (See Cones, Pyrometric)

SEISMOGRAPHS
Akatos, Inc.
Alpha Instrument Co.
American Inst. Co.
Am. Telescope Labs.
Engineering Labs., Inc.
Geophysical Instrument
Heiland Research Corp.
Mico Instrument Co.
Ruska & Co., Inc.

SELF-OPERATING CONTROLLERS & REGULATORS AUTOMATIC
Am. Automatic Elec.
American Inst. Co.
Arca Regulators, Inc.
Bailey Meter Co.
Betts & Betts

SELF-OPERATING CONTROLLERS & REGULATORS, AUTOMATIC (Cont'd)
Brown Inst. Co.
Cutler-Hammer, Inc.
D'Este Co.
Dickson Co.
Elec. Indicator Corp.
Hanlon-Waters, Inc.
Lammert & Mann Co.
Leeds & Northrup Co.
Leslie Co.
Mason-Neilan Regulator
Partlow Corp.
Penn Electric Switch Co.
Perfex Corp.
Ruggles-Klingemann
Scientific Inst. Co.
Taplabue Mfg. Co.
Taylor Inst. Cos.
United Transformer

SERVO-MOTORS, Electric Motor
Brown Inst. Co.
Eclipse Aviation
General Regulator Corp.
L. A. B. Corp.

SERVO-MOTORS, Electric Solepoid
Brown Inst. Co.
Eclipse Aviation
Hagan Corp.
Ruggles-Klingemann

SERVO-MOTORS, Hydraulic
Allis-Chalmers Mfg. Co.
Askania Regulator Co.
Eclipse Aviation
General Regulator Corp.
Hagan Corp.
Mason-Neilan Regulator
Ruggles-Klingemann

SERVO-MOTORS, Mechanical
Hagan Corp.

SERVO-MOTORS, Pneumatic
Askania Regulator Co.
Brown Inst. Co.
Hagan Corp.
Mason-Neilan Regulator

SEXTANTS
Alpha Instrument Co.
Keuffel & Esser Co.
Master Optical Co.
Negus, T. S. & J. D.
Pioneer Instrument Co.
Warren-Knight Co.
White Co., Inc.

SHIP LOGS
Elec. Tachometer Corp.
Kenyon Instrument Co.
Negus, T. S. & J. D.
Pitometer Log Corp.

SHUNT METERS (See Meters, Shunt)

SHUNTS
Burton-Rogers Co.
Columbia Elec. Mfg.
Esterline-Angus Co.
General Elec. Co.
Hickok Elec. Inst. Co.
International Resistance
Precision Resistor Co.
Radio City Products Co.
Rawson Electrical Inst.
Roller-Smith Co.
Rubicon Co.
Sensitive Research Inst.
Triplett Electrical Inst.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

SHUNTS, Standard
Cambridge Instrument Co.
Esterline-Angus Co.
General Electric Co.
Gray Instrument Co.
Hickok Electrical Inst.
Instrument Resistors, Inc.
International Resistance
Leeds & Northrup Co.
Roller-Smith Co.
Rubicon Co.
Triplett Elec. Inst. Co.
Weston Elec. Inst. Corp.

SIEVE SHAKERS
Braun Corp.

SIEVES, TESTING
American Inst. Co.
Central Scientific Co.
Dietert Co.
Fisher Scientific Co.
Humboldt Mfg. Co.
Precision Scientific Co.
Riehle Division
Scientific Inst. Co.
Weber Brothers Metal

SIGHT METERS
General Elec. Co.
G-M Labs.
Weston Elec. Inst. Corp.

SIGHTS, GUN, Telescopic
Clark & Sons
Fecker, J. W.
Kollmorgen Optical Co.
Perkin, Elmer & Moffitt
Zeiss, Inc., Carl

SIGNAL GENERATORS (See Generators, Signal)

SIGNALING DEVICES, Automatic
American Automatic Elec.
Autocall Co.
Betts & Betts
Ballard Co.
Cincinnati Time Rec.
Elec. Indicator Corp.
Foxboro Co.
General Elec. Co.
Guardian Elec. Mfg. Co.
International Bus. Mach.
Leslie Co.
Production Instrument
Spence Engineering Co.
Thompson Clock Co.
United Cinephone Corp.

SIGNALING DEVICES, Traffic
Am. Gas Accumulator
Ballard Co.
Eagle Signal Corp.
Edison Electrical Controls
Sangamo Electric Co.

SILICA, VITREOUS
Thermal Syndicate, Ltd.

SINE BARS
Ford Motor Co.

SLIDE RULES (See Drawing Instruments)

SLIDING GAGES (See Gages, Sliding)

SLOW MOTION STUDY EQUIPMENT
Annis Co.
Boulin Instrument Corp.
Commercial Engg. Labs.
Warren Telechron Co.

SLUMP CONES (See Cones, Slump)

SMOKE DENSITY, Indicators & Recorders
Associated Research
Bailey Meter Co.
Boiler Room Equip.
Bristol Co.
Denver Fire Clay Co.
Dickson Co.
Electronic Lab.
Ess Instrument Co.
General Elec. Co.
General Television Corp.
Leeds & Northrup Co.
Lumenite Elec. Co.
Luxtrol Co., Inc.
McNeill Eng. Equip.
Photobell Corp.
Photoswitch, Inc.
Preferred Utilities Mfg.
Rehtron Corp.
United Cinephone Corp.
Weston Elec. Inst. Corp.

SOLAR PROJECTING SCREEN (See Screen, Solar Projecting)

SOUND INDICATORS & ANALYZERS (See Indicators, Sound & Analyzers, Sound)

SOUND LEVEL METERS
Ballantine Labs.
Clough-Brengle Co.
Daven Co.
Electrical Research Prod.
Electronic Design Corp.
General Elec. Co.
General Radio Co.
Jones-Orme Co.
Precision Apparatus Corp.
Radio City Products Co.
Shallcross Mfg. Co.
Sound Apparatus Co.
Triplett Electrical Inst.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

SOUNDING LEADS
Ballauf Mfg. Co.
Bliss & Co.
Kenyon Instrument Co.
Moeller Instrument Co.
Negus, T. S. & J. D.

SOUNDING MACHINES
Ballauf Mfg. Co.
Bendix Marine Products
Kenyon Instrument Co.
Moeller Instrument Co.
Negus, T. S. & J. D.
Submarine Signal Co.

SOUNDING TUBES
Ballauf Mfg. Co.
Kimble Glass Co.
Moeller Instrument Co.
Negus, T. S. & J. D.

SPECIFIC GRAVITY Indicators & Recorders
American Meter Co.
Bailey Meter Co.
Binckley G. S.
Elmer & Amend
Foxboro Co.
Refinery Supply Co.
G. M. Mfg. Co.
Ruchfel Co.
Schultheis Corp.
Scientific Inst. Co.
Taplabue Mfg. Co.
Taylor Inst. Cos.
Trerice Co.

SPECTRA DEMONSTRATORS
Baird Associates
Central Scientific Co.
Eastern Science Co.
Fuess, Inc.
Gaertner Scientific Corp.

SPECTRAL TUBES CONTAINING RARE GASES (See Spectrum Tubes)

SPECTROGRAPHS
Akatos, Inc.
Bausch & Lomb Optical
Bryden Co.
Gaertner Scientific Corp.
Spencer Lens Co.
Zeiss, Inc., Carl

SPECTROGRAPHS, Diffraction Grating
Applied Research Labs.
Baird Associates

SPECTROGRAPHS, Oscillating
Hayes Scientific App.

SPECTROGRAPHS, Vacuum
Central Scientific Co.
Dietert Co.
Fecker, J. W.
Fuess, Inc.

SPECTROGRAPHS, X-ray
Central Scientific Co.
Fuess, Inc.
Gaertner Scientific
General Electric X-Ray
Hayes Scientific App.
Kelley-Koett Mfg.

SPECTROMETERS
Akatos, Inc.
American Askania Corp.
Bausch & Lomb Optical
Fuess, Inc.
Spencer Lens Co.

SPECTROMETER, Infra-Red
Gaertner Scientific Corp.

SPECTROMETERS, X-RAY (See Spectographs, X-Ray)

SPECTRO-PHOTOMETERS (See Photometers, Spectro)

SPECTROSCOPES
Akatos, Inc.
American Askania Corp.
Fuess, Inc.
Gaertner Scientific Corp.
Leitz, Inc.
Spencer Lens Co.

SPECTROSCOPE, Quartz
Gaertner Scientific Corp.

SPECTROSCOPES, Stellar
Am. Telescope Labs.
Central Scientific Co.
Eastern Science Co.

SPECTROSCOPES, Stellar (Cont'd)
Fecker, J. W.
Mico Instrument Co.
Perkin, Elmer & Moffitt
Zeiss, Inc., Carl

SPECTRUM TUBES
Central Scientific Co.
Fuess, Inc.
Gaertner Scientific Corp.
General Physical Lab.

SPEED, Indicators
Amthor Testing Inst. Co.
Bailey Meter Co.
Biddle Co., Jas. G.
Boulin Instrument Corp.
Brown Inst. Co.
Commercial Engg. Labs.
Consol. Ashcroft Hancock
Cramer & Co., Inc.
Electric Speed Ind. Co.
Elec. Tachometer Corp.
Esterline-Angus Co.
Foxboro Co.
Gaertner Scientific Corp.
General Elec. Co.
Hasler-Tel Co.
Hathaway Inst. Co.
Hickok Elec. Inst. Co.
Jaeger Watch Co.
Leeds & Northrup Co.
Martin Decker Corp.
McDonnell Odometer Co.
Misener Mfg. Co., Inc.
Moisture Register Co.
Precision Therm. & Inst.
Scherr Co., Inc.
Sound Apparatus Co.
Starrett Co.
Stucht & Co.
Veeder-Root, Inc.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.
Zernickow Co., O.

SPEED, Recorders (See Speed Indicators)

SPEED, Regulators (See Controllers, Automatic, Tachometric)

SPEED SYNCHRONIZING INDICATOR
Electric Speed Ind. Co.

SPEEDOMETERS
Boulin Instrument Corp.
Central Scientific Co.
Corbin Screw Corp.
Cramer & Co., Inc.
Elec. Tachometer Corp.
General Elec. Co.
Stewart-Warner Corp.
Westinghouse Elec. & Mfg.

SPHEROMETER
American Askania Corp.
Central Scientific Co.
Fish-Schurman Co.
Fuess, Inc.
Gaertner Scientific Corp.

SPHYGMOMANOMETERS
Cambridge Inst. Co.
Central Scientific Co.
Hellige, Inc.
Precision Therm. & Inst.
Taylor Inst. Cos.

SQUARES Combination & Machinists'
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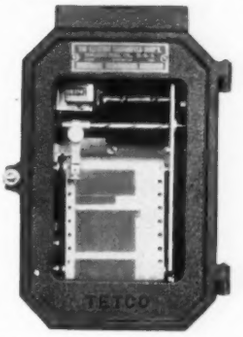

Creates a permanent time record on a waxed chart. Accurately records rate of production, time and duration of stops, total quantity produced.

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For addresses, see pages 56-64

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Hellige, Inc.
Munsell Color Co.
Tagliabue Mfg. Co.
STANDARDS E.m.f.
Cambridge Inst. Co.
Leeds & Northrup Co.
Rubicon Co.
STANDARDS, Frequency
Andrew, Victor J.
Ferris Inst. Corp.
General Radio Co.
STANDARDS, Inductance
Cambridge Inst. Co.
General Radio Co.
Leeds & Northrup Co.
Rubicon Co.
STANDARDS, Length
Gaertner Scientific Corp.
Gurley, W. & L. E.
Van Keuren Co.
STANDARDS, Mass
Gurley, W. & L. E.
Sorderer-Kohlbusch, Inc.
STANDARDS, Potential
Leeds & Northrup Co.
Rubicon Co.
STANDARDS, Pressure
Green, Henry J.
Holz, Herman A.
Precision Therm. & Inst.
STANDARDS, Resistance
Beck Bros.
Cambridge Inst. Co.
General Radio Co.
International Resistance
Leeds & Northrup Co.
Rubicon Co.
Shallcross Mfg. Co.
Stricht & Co.
Ward Leonard Elec. Co.
STANDARDS, Sound Level
General Radio Co.
STANDARDS, Temperature
Green, Henry J.
Leeds & Northrup Co.
Moeller Instrument Co.
Precision Therm. & Inst.
Tagliabue Mfg. Co.
STANDARDS, Time
Gaertner Scientific Corp.
General Radio Co.
Standard Elec. Time Co.
STANDARDS, Volume
Gurley, W. & L. E.
STARTERS, MOTOR
Allen-Bradley Co.
Allis-Chalmers Mfg. Co.
Cutler-Hammer, Inc.
Eclipse Aviation
General Elec. Co.
Monitor Controller Co.
Penn Electric Switch Co.
Schaefer Bros. Co.
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General Elec. Co.
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Bausch & Lomb Optical
Kelley-Koett Mfg. Co.
Westinghouse X-Ray Co.
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Brush Development Co.
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Robinson Orifice Fitting
Zink Co., John
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STRAIN TESTERS, GLASS (See Testers, Strain (Glass)
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Cambridge Inst. Co.
Holz, Herman A.
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Gurley, W. & L. E.
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Morey & Jones, Ltd.
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Baldwin-Southwark Corp.
Cambridge Inst. Co.
Holz, Herman A.
Martin Decker Corp.
Riehle Div.
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Ames Co., B. C.
Baldwin-Southwark Corp.
Holz, Herman A.
STRESS-STRAIN, Recorders
Baldwin-Southwark Corp.
Cambridge Inst. Co.
Holz, Herman A.
Olsen Testing Machine
Riehle Div.
STROBOSCOPES
Boulin Inst. Corp.
Commercial Engg. Labs.
L. A. B. Corp.
Welch Mfg. Co.
Westinghouse Elec. & Mfg.
Zeiss, Inc., Carl
SULPHUR BOMBS (See Bombs, Su'phur)
SULPHUR DIOXIDE, Indicators (See Gas Analyzers, Sulphur Dioxide) **Recorders** (See Gas Analyzers, Sulphur Dioxide)
SUNSHINE, Indicators & Recorders
Cambridge Inst. Co.
Esterline-Angus Co.
Friez & Sons
Fuess, Inc.
G. M. Mfg. Co., Inc.
Leeds & Northrup
Luxtrol Co., Inc.
Taylor Inst. Cos.
White Co. Inc.
SUPERVISORY CONTROL EQUIPMENT
American Automatic Elec.
Autocall Co.
Bristol Co.
Cramer & Co., Inc.
General Elec. Co.
Guardian Elec. Mfg. Co.
Leeds & Northrup Co.
Tagliabue Mfg. Co.
SURFACE GAGES (See Gages, Surface)
SURFACE PLATES, GLASS
Bausch & Lomb Optical
Clark & Sons
Fenker, J. W.
Fish-Schurman Co.
Zeiss, Inc., Carl
SURGE CREST AMMETERS (Ammeters, Surge-Crest)
SURGE, Indicators & Recorders
Elec. Indicator Corp.
General Elec. Co.
Esterline-Angus Co.
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Alpha Instrument Co.
Beckman Co.
Berger & Sons
Bliss & Co.
Dietzen Co.
Gurley, W. & L. E.
Kenyon Instrument Co.
Kern Co.
Keuffel & Esser Co.
Kolesch & Company
Leupold, Volpel & Co.
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Post Co., Frederick
Speedometer Service Co.
Speidel & Co.
J. C. Ulmer Co.
United States Blue Print
Warren-Knight Co.
Weber Co.
White Co. Inc.
Zeiss, Inc., Carl
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Am. Paulin System
SURVEYING INSTRUMENTS, Underground, for wells or bore holes
H. Cole Co.
Driftmeters, Inc.
Engineering Labs., Inc.
Geophysical Inst. Co.
Halliburton Oil Well
Ruska & Co.
Sperry-Sun Well Survey.
Warren-Knight Co.
David White Co. Inc.
SURVEYOR'S CHAINS (See Surveying Instruments)
SWITCHES, Air-operated
Detroit Lubricator Co.
Johnson Service Co.
Shallcross Mfg. Co.
Tagliabue Mfg. Co.
SWITCHES, Automatic Transfer
Allen-Bradley Co.
Anderson, A. & J. M.
Arrow-Hart & Hegeman
Autocall Co.
Automatic Switch Co.
Cramer & Co., Inc.
Cutler-Hammer, Inc.
General Elec. Co.
Hart Mfg. Co.
Monitor Controller Co.
Ward Leonard Elec. Co.
Zenith Electric Co.
SWITCHES, Instrument
Autocall Co.
Furnas Electric Co.
General Elec. Co.
Kellogg Switchboard
Rubicon Co.
Sensitive Research Inst.
Thwing-Albert Instrument
Triplett Elec. Inst. Co.
Weston Elec. Inst. Corp.
SWITCHES, Magnetic
Allen-Bradley Co.
Arrow-Hart & Hegeman
Autocall Co.
Automatic Switch Co.
Cutler-Hammer, Inc.
General Elec. Co.
Guardian Elec. Mfg. Co.
Hart Mfg. Co.
Industrial Engr. Corp.
Monitor Controller Co.
Penn Electric Switch
Perfex Corp.
Struthers-Dunn
Ward Leonard Elec. Co.
Zenith Electric Co.
SWITCHES, Mercury
Arrow-Hart & Hegeman
Continental Elec. Co.
Elec. Switch Corp.
General Elec. Co.
Gen. Elec. Lamp Dept.
Hart Mfg. Co.
SWITCHES, Pyrometer
J-B-T Insts. Inc.
Lewis Engg. Co.
Tagliabue Mfg. Co.
Thwing-Albert Inst. Co.
Weston Elec. Inst. Corp.
Woermann-Schuchhardt
SWITCHES, Relay
Allen-Bradley Co.
Andrew, Victor J.
Amer. Automatic Elec.
Arrow-Hart & Hegeman
Autocall Co.
Automatic Switch Co.
Cutler-Hammer, Inc.
Eclipse Aviation
Edison Electrical Controls
Friez & Sons
General Controls Co.
General Elec. Co.
Guardian Elec. Mfg. Co.
Hart Mfg. Co.
Industrial Engr. Corp.
Kellogg Switchboard
Monitor Controller Co.
Penn Electric Switch
Perfex Corp.
Standard Elec. Prods.
Struthers-Dunn
Ward Leonard Elec. Co.
Zenith Electric Co.
SWITCHES, Rotary
Amer. Automatic Elec.
Arrow-Hart & Hegeman
Autocall Co.
Furnas Electric Co.
General Elec. Co.
Guardian Elec. Mfg. Co.
Hart Mfg. Co.
Lewis Engg. Co.
Rubicon Co.
Sensitive Research Inst.
Shallcross Mfg. Co.
SWITCHES, Rotary (Cont'd)
Tagliabue Mfg. Co.
Thwing-Albert Inst. Co.
Triplett Electrical Inst.
Weston Elec. Inst. Corp.
SWITCHES, Snap
Arrow-Hart & Hegeman
Cutler-Hammer, Inc.
General Elec. Co.
Hart Mfg. Co.
McDonnell & Miller
Micro Switch Corp.
Perfex Corp.
Ward Leonard Elec. Co.
SWITCHES, Thermostatic
Advance Electric Co.
Allen-Bradley Co.
Burling Instrument Co.
Cook Electric Co.
Detroit Lubricator Co.
Dunn, Inc., Struthers
Edison Electrical Controls
Friez & Sons
Gleason-Avery, Inc.
Hart Manufacturing Co.
Penn Electric Switch Co.
Perfex Corp.
Shallcross Mfg. Co.
Spencer Thermostat Co.
Tagliabue Mfg. Co., C. J.
Ulanet Co., George
Ward Leonard Electric Co.
SWITCHES, Time
American Timer Corp.
Anderson, A. & J. M.
Autocall Co.
Automatic Elec. Mfg.
Cramer & Co., Inc.
Eagle Signal Corp.
Edison Electrical Controls
Frober-Faybor Co.
General Elec. Co.
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WESTON *Instruments*

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Guard an Elec. Mfg. Co.
Industrial Engr. Corp.
Industrial Instrument Co.
Landis & Gyr, Inc.
Paragon Electric Co.
Penn Electric Switch
Perfex Corp.
Rhodes, Inc., **M. H.**
Sangamo Electric Co.
States Co.
Thomas Clock Co., Seth
Thompson Clock Co.
Wadsworth Elec. Mfg. Co.
Walser Automatic Timer
Ward Leonard Elec. Co.
Zenith Electric Co.

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SYNCHRONOUS MOTORS (See Motors, Synchronous)

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Eclipse Aviation
Electric Controller
General Elec. Co.
Hickok Elec. Inst. Co.
Kollsman Inst. Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

TACHOGRAPHS
Amthor Testing Inst.
Biddle Co., Jas. G.
Coats Mach. Tool Co.
Cramer & Co., Inc.
Ohmer Register Co.
Zeiss, Inc., Carl
Zernickow Co., O.

TACHOMETER TESTERS (See Testers, Tachometer)

TACHOMETERS, Centrifugal
Amthor Testing Inst. Co.
Barbour Stockwell Co.
Biddle Co., Jas. G.
Boulin Instrument Corp.
Coats Mach. Tool Co.
Consol. Ashcroft Hancock
Corbin Screw Corp.
Durant Mfg. Co.
Elec. Tachometer Corp.
Foxboro Co.
Hays Corp.
Jones Motrola Sales
Kollsman Inst. Co.
Pioneer Instrument Co.
Scherr Co., Inc.
Stewart-Warner Corp.
Sticht & Co.
Veeder-Root, Inc.
Viking Instrument Co.
Zernickow Co., O.

TACHOMETERS, Chronometric
Amthor Testing Inst.
Biddle Co., Jas. G.
Boulin Instrument Corp.
Coats Mach. Tool Co.
Cramer & Co., Inc.
Elec. Tachometer Corp.
Elgin Nat'l Watch Co.
Hasler-Tel Co.
Jaeger Watch Co.
Pierce Watch Co.
Scherr Co., Inc.
Standard Elec. Time
Sticht & Co.
Stover-Lang Co.
Zernickow Co., O.

TACHOMETERS, Cross-pendulum
Amthor Testing Inst.
Biddle Co., Jas. G.
Coats Mach. Tool Co.
Sticht & Co.
Zernickow Co., O.

TACHOMETERS, Electric
Allen Elec. & Equip.
Bristol Co.
Brown Inst. Co.
Electric Speed Ind. Co.
Elec. Tachometer Corp.
Esterline-Angus Co.
Foxboro Co.
General Elec. Co.
Hathaway Inst. Co.
Hickok Elec. Inst. Co.
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Pitometer Log Corp.
Potter Co.
Scherr Co., Inc.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.
Zip Abrasive Co.

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Jaeger Watch Co.
Kollsman Inst. Co.
National Instrument Co.
Standard Elec. Time Co.
Stewart-Warner Corp.
Zernickow Co., O.

TACHOMETERS, Fly-ball
Biddle Co., Jas. G.
Coats Mach. Tool Co.
Elec. Tachometer Corp.
Jones Motrola Sales
Sticht & Co.
Viking Instrument Co.

TACHOMETERS, Portable
Amthor Testing Inst. Co.
Biddle Co., Jas. G.
Boulin Instrument Corp.
Consol. Ashcroft Hancock
Corbin Screw Corp.
Elec. Tachometer Corp.
Foxboro Co.
Hasler-Tel Co.
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TACHOMETERS, Speed Limit Control
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TACHOMETERS, Stroboscopic
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Stewart-Warner Corp.

TACHOMETERS, Tilting-ring
Amthor Testing Inst. Co.
Coats Mach. Tool Co.

TACHOMETERS, Vibrating Reed
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Biddle Co., Jas. G.
Scherr Co., Inc.
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TAPES, Oil Gauger's
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TAPES, Steel
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Kollmorgen Optical Co.
Keuffel & Esser Co.
Pierce Watch Co.

TELESCOPES, Alignment
Am. Telescope Labs.
Fecker, J. W.
Gen. Engg. & Model Wks.
Keuffel & Esser Co.
Kollmorgen Optical Co.
Perkin, Elmer & Moffitt
Scherr Co., Inc.
White Co., Inc.

TELESCOPES, Astronomical
Am. Telescope Labs.
Clark & Sons
Eastern Science Co.
Fecker, J. W.
Gaertner Scientific Corp.
Kern Co.
Mico Instrument Co.
Perkin, Elmer & Moffitt
Tinsley Labs.
Zeiss, Inc., Carl

TELESCOPES, Azimuth
Am. Telescope Labs.
Clark & Sons
Fecker, J. W.
Gaertner Scientific Corp.
Kern Co.
Kollmorgen Optical Co.
Perkin, Elmer & Moffitt
Tinsley Labs.
Warren-Knight Co.
Warner & Swasey Co.
Zeiss, Inc., Carl

TELESCOPES, Bore, Inspection
Am. Telescope Labs.
Gen. Engg. & Model Wks.
Kollmorgen Optical Co.
Perkin, Elmer & Moffitt
Scherr Co., Inc.
Zeiss, Inc., Carl

TELESCOPES, Laboratory
Gaertner Scientific Corp.

TELESCOPES, Reflecting
Am. Telescope Labs.
Clark & Sons
Fecker, J. W.
Fish-Schurman Co.
Perkin, Elmer & Moffitt
Tinsley Labs.
Warner & Swasey Co.
Zeiss, Inc., Carl

TELESCOPES, Refracting
Am. Telescope Labs.
Clark & Sons
Fecker, J. W.
Fish-Schurman Co.
Kern Co.
Keuffel & Esser Co.
Perkin, Elmer & Moffitt
Tinsley Labs.

TELESCOPES, Refracting (Cont'd)
Warner & Swasey Co.
Wollensak Optical Co.
Zeiss, Inc., Carl

TELESCOPES, Zenith
American Askania Corp.
Am. Telescope Labs.
Clark & Sons
Fecker, J. W.
Gaertner Scientific Corp.
Kern Co.
Perkin, Elmer & Moffitt
Zeiss, Inc., Carl

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Geophysical Inst. Co.
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Olsen Testing Machine
Suter, Alfred
Thwing-Albert
Toledo Scale Co.

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Seederer-Kohlbusch, Inc.

TENSION INDICATORS, Textile
Boulin Instrument Corp.
Holz, Herman A.

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Ford Motor Co.
Holz, Herman A.

TEST BLOCKS (Cont'd)
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Steel City Testing Lab.
Van Keuren Co.

TEST WEIGHTS (See Weights, Test)

TEST WELLS
Palmer Co.

TESTERS, Tachometer
Rieker Inst. Co.

TESTERS & TESTING MACHINES (See also object of measurement and control)

TESTERS & TESTING MACHINES, Abrasion
American M. A. N. Corp.
Amthor Testing Inst. Co.
Atlas Elec. Devices Co.
Fidelity Mach. Co.
Holz, Herman A.
Morehouse Machine Co.
Olsen Testing Machine
Riehle Div.
Saxl Inst. Co.
Scott Co., Henry L.
Shawmut Engineering Co.
Suter, Alfred
Taber Instrument Co.
Testing Machines, Inc.
Zuhr, Inc., Henry

TESTERS & TESTING MACHINES, Absorption
Gurley, W. & L. E.

TESTERS & TESTING MACHINES, Air Speed Indicator (See Air-speed Indicator Testers)

TESTERS & TESTING MACHINES, Alternating Stress
American M. A. N. Corp.
Brush Development Co.
Emery Co.
Holz, Herman A.
Krouse Fatigue Machine
Olsen Testing Machine
Riehle Div.
Suter, Alfred

TESTERS & TESTING MACHINES, Altimeter (See Altimeter Testers)

TESTERS & TESTING MACHINES, Armature
Ideal Commutator Dresser

TESTERS & TESTING MACHINES, Asphalt
American Inst. Co.
Atlas Electric Devices
Brabender Corp.
Braun Corp.
Central Scientific Co.
Chatillon & Sons
Exact Weight Scale
Fish-Schurman Co.
Fisher Scientific Co.
Humboldt Mfg. Co.
Philadelphia Thermometer
Precision Scientific Co.
Riehle Div.
Tagliabue Mfg. Co.
Victor Equipment Co.
Western Machinery Co.

TESTERS & TESTING MACHINES, Axle
Sperry Products, Inc.

TESTERS & TESTING MACHINES, Ball Bearing (See Testers, Bearing)

TESTERS & TESTING MACHINES, Battery
Allen Elec. & Equip. Co.
Burton-Rogers Co.
Clough-Brengle Co.
Hickok Elec. Inst. Co.
Hy-Ef Electrical Prods.
Instrument Specialties Co.
Lantz-Phelps Corp.
Lundquist Tool & Mfg.
Precision Therm. & Inst.
Rascher & Betzold
Rieker Inst. Co.
Ruth Glass Division
Testrite Instrument Co.
Weston Elec. Inst. Corp.

TESTERS & TESTING MACHINES, Beating
American M. A. N. Corp.
Holz, Herman A.
Olsen Testing Machine
RCA Manufacturing Co.
Suter, Alfred

TESTERS & TESTING MACHINES, Bearing
Brabender Corp.
Green, Arthur B.
Williams Apparatus Co.

TESTERS & TESTING MACHINES, Bending
American M. A. N. Corp.
Dorr-Patterson Engr.
Hayes Scientific App.
Olsen Testing Machine
Holz, Herman A.
Morehouse Machine Co.

(Continued on next page)

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FOR SURFACE FINISHES

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and WASHING

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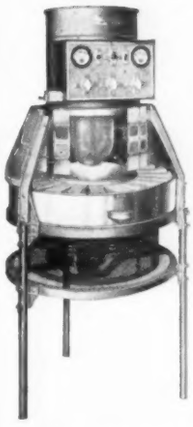

for duplicating effects of sunlight on dyestuffs, textiles, inks, paper, rubber and other colored materials.

June sunlight plus in your laboratory.

Weather-Ometer

for duplicating effects of weathering on paints, varnishes, lacquers, enamels, asphalts, roofings, wire and other protective coatings used outdoors.

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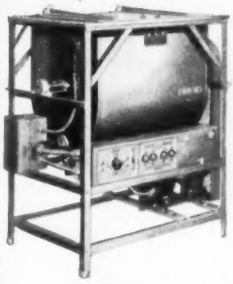

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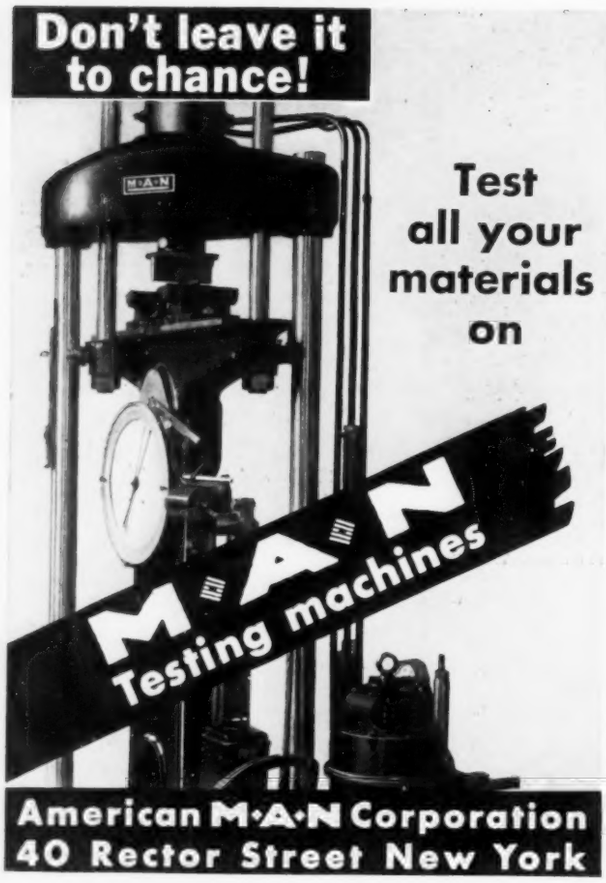

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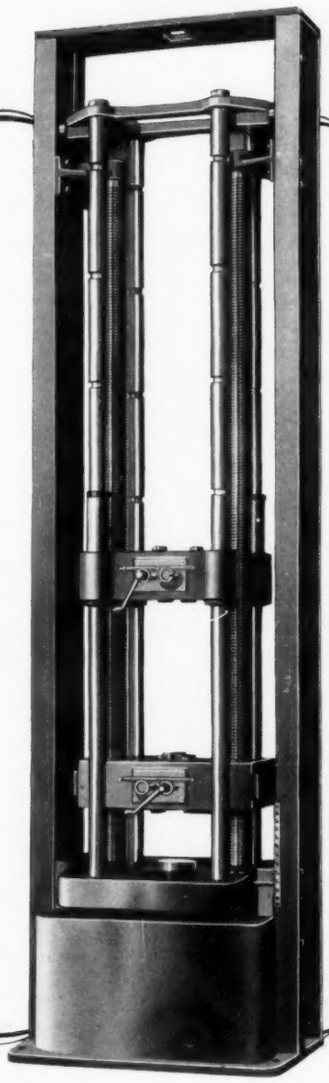
(TESTING Mach. Cont'd on page 48)

For addresses, see pages 56-64



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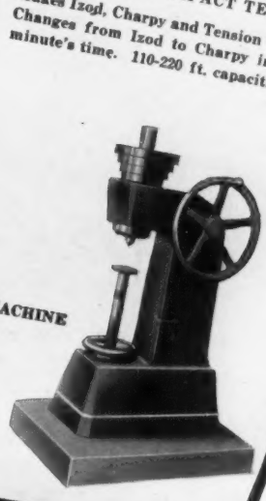

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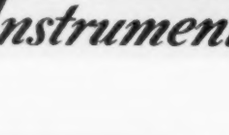

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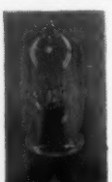

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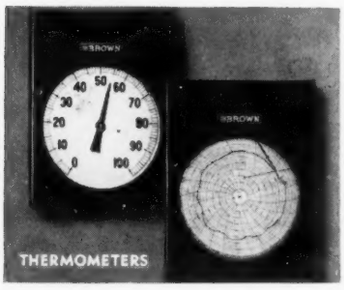

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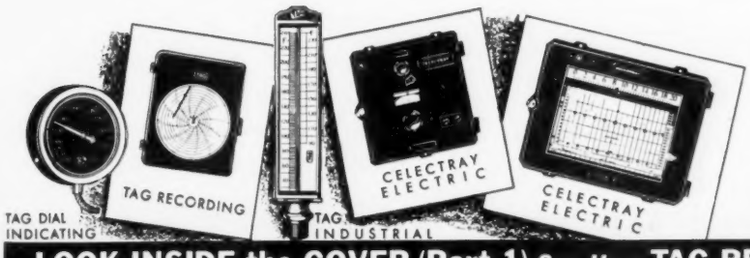

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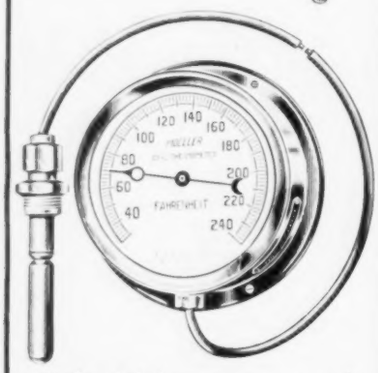

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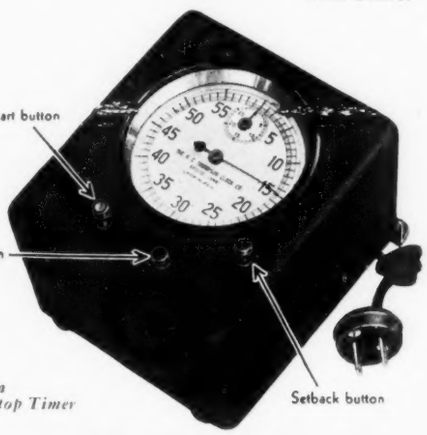

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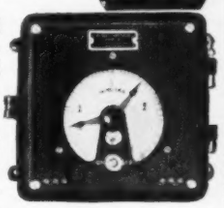

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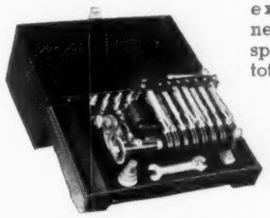

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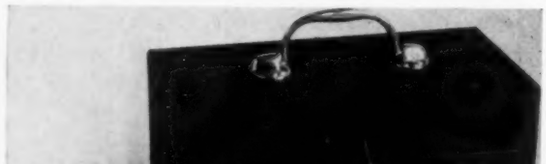

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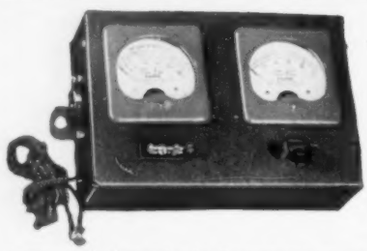

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This gauge successfully used by many of America's foremost manufacturers.

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Taylor Inst. Cos.
Tefft-Jackson, Inc.

VALVES, Automatic Shut-off
Automatic Switch Co.
Automatic Valve Control
Belfield Co.
Brown Inst Co.
Davis Reg. Co.
Fisher Governor Co.
Foster Engg. Co.
Frick Co.
Friez & Sons
General Controls Co.
General Sales & Prod.
Hagan Corp.
Hanlon-Waters, Inc.
Jerguson Gage Co.
Kiely & Mueller
McAlear Mfg. Co.
McDonnell & Miller
Partlow Corp.
Ruggles-Klingemann
Payne Furnace & Supply
Schade Valve Mfg. Co.
Tagliabue Mfg. Co.
Wilgus Mfg. Co.

VALVES, Automatic Solenoid (See Valves, Solenoid)

VALVES, Balanced
American Meter Co.
Atlas Valve Co.
Bailey Meter Co.
Belfield Co.
Boylston Co.
Bristol Co.
Cash Co.
Cochrane Corp.
Connelly Iron Sponge
Davis Reg. Co.
Defender Automatic Reg.
D'Este Co.
Fisher Governor Co.
Ford Reg. Valve Co.
Foster Engg. Co.
General Controls Co.
Hagan Corp.
Hanlon-Waters, Inc.
Illinois Eng. Co.
Industrial Instrument
Jenkins Bros.
Kiely & Mueller
Klinfel Mfg. Co.
Mason-Neilan Regulator
McAlear Mfg. Co.
Natural Gas Equipment
Northern Equip. Co.
Powers Regulator Co.
Republic Flow Meters
Reynolds Gas Regulator
Ruggles Klingemann
Schade Valve Mfg. Co.
Spence Engineering Co.
Tagliabue Mfg. Co.
Watts Regulator Co.
Wilgus Manufacturing

VALVES, Constant Pressure
Bailey Meter Co.
Belfield Co.
Cash Co.
Connelly Iron Sponge
Davis Reg. Co.
D'Este Co.
Dockson Co.
Fisher Governor Co.
Foster Engg. Co.
Hagan Corp.
Hanlon-Waters, Inc.
Hoke, Inc.
Jenkins Bros.
Klinfel Mfg. Co.
Mason-Neilan Regulator
McAlear Mfg. Co.
Powers Regulator Co.
Refrigerating Spec. Co.
Reynolds Gas Regulator
Ruggles-Klingemann
Schade Valve Mfg. Co.
Spence Engineering Co.
Tagliabue Mfg. Co.
Vaughn-G E Witt Co.
Wilgus Manufacturing

VALVES, Diaphragm
Askania Regulator Co.
Atlas Valve Co.
Bailey Meter Co.
Bastian-Blessing Co.
Belfield Co.
Boylston Co.
Bristol Co.
Brown Inst. Co.
Cash Co.
Connelly Iron Sponge
Consol. Ashcroft Hancock
Davis Reg. Co.
Defender Automatic Reg.
D'Este Co.
Foster Engg. Co.
Foxboro Co.
General Controls Co.
Hagan Corp.
Hanlon-Waters, Inc.
Illinois Eng. Co.
Industrial Instrument
Johnson Service Co.
Kiely & Mueller
Klinfel Mfg. Co.
Leslie Co.
Mason-Neilan Regulator
McAlear Mfg. Co.
McCorkle Co.
National Airoil Burner
Natural Gas Equipment
Partlow Corp.
Payne Furnace & Supply
Powers Regulator Co.
Refrigerating Spec. Co.
Republic Flow Meters Co.
Reynolds Gas Regulator
Ruggles-Klingemann
Schade Valve Mfg. Co.
Scientific Instrument Co.
Spence Engineering Co.
Spencer Thermostat Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Vaughn-G E Witt
White-Rodgers Electric
Wilgus Manufacturing

VALVES, Electrically Operated
Atkins & Co.
Atlas Valve Co.
Automatic Products Co.
Automatic Switch Co.
Automatic Temp. Control
Bristol Co.
Brown Inst. Co.
Cochrane Corp.
Cutler-Hammer, Inc.
Davis Reg. Co.
Defender Automatic Reg.
Detroit Lubricator Co.
Electric Valve Mfg.
Electrimatic Corp.
Foster Engg. Co.
Foxboro Co.
Frick Co.
Friez & Sons
General Controls Co.

VALVES, Electrically Operated (Cont'd)
Hannifin Mfg. Co.
Hunt & Son
Illinois Eng. Co.
Jenkins Bros.
Kiely & Mueller
Klinfel Mfg. Co.
Leslie Co.
Magnatrol Valve Corp.
Mason-Neilan Regulator
McAlear Mfg. Co.
McCorkle Co.
McDonnell & Miller
Northern Equipment Co.
Payne Furnace & Supply
Penn Electric Switch
Perfex Corp.
Refrigerating Spec. Co.
Ross Operating Valve
Ruggles-Klingemann
Schade Valve Mfg. Co.
Shalleross Mfg. Co.
Spence Engineering Co.
Supreme Elec. Prods.
Tagliabue Mfg. Co.
White-Rodgers Elec. Co.

VALVES, Hydraulically Operated
Arca Regulators, Inc.
Askania Regulator
Atlas Valve Co.
Auto Temp Control
Bailey Meter
Barber-Coleman Co.
Cash Co.
Controls, Inc.
Defender Automatic Reg.
Foster Engg. Co.
Gen. Electric Co.
Hagan Corp.
Hays Corp.
Jenkins Bros.
Kiely & Mueller
Leslie Co.
Mason-Neilan Regulator
McAlear Mfg. Co.
Powers Regulator Co.
Republic Flow Meter
Ruggles-Klingemann
Schade Valve Mfg. Co.
Spence Engineering Co.
Sterling Eng. Co.

VALVES, Lubricated Plug
Merco Nordstrom Valve

VALVES, Motor Operated (See Valves, Diaphragm; Valves, Electrically-operated; Valves, Hydraulically - operated; Valves, Solenoid)

VALVES, Pressure Relief, Reducing, etc.
Abercrombie Pump Co.
American Meter Co.
Ashton Valve Co.
Atlas Valve Co.
Bailey Meter Co.
Bastian-Blessing Co.
Boylston Co.
Brown Instr. Co.
Cash Co.
Cochrane Corp.
Connelly Iron Sponge
Consol. Ashcroft Hancock
Crosby Steam Gage Co.
Davis Reg. Co.
D'Este Co.
Detroit Lubricator Co.
Fisher Governor Co.
Foster Engg. Co.
Foxboro Co.
Fulton Sylphon Co.
Hagan Corp.
Hanlon-Waters, Inc.
Hoke, Inc.
Illinois Eng. Co.
Industrial Instrument
Kenyon Instrument Co.
Kiely & Mueller
Klinfel Mfg. Co.
Lammert & Mann Co.
Leslie Co.
Marsh Corp., Jas. P.
Mason-Neilan Regulator
McAlear Mfg. Co.
Natural Gas Equipment
Powers Regulator Co.
Republic Flow Meters
Ruggles-Klingemann
Schade Valve Mfg. Co.
Spence Engineering Co.
Spencer Thermostat Co.
Star Brass Mfg. Co.
Tagliabue Mfg. Co.
Taylor Instr. Cos.
Vapor Recovery Systems
Vaughn-G. E. Witt Co.
Victor Equipment Co.
Watts Regulator Co.
Wilgus Manufacturing

VALVES, Proportional Air-Gas
American Meter Co.
Bristol Co.
Brown Inst. Co.
Cash Co.
Connelly Iron Sponge
Fisher Governor Co.
Hagan Corp.
Hanlon-Waters, Inc.
Lammert & Mann Co.
Mason-Neilan Regulator
McAlear Mfg. Co.
Tagliabue Mfg. Co.

VALVES, Regulating
Am. Gas Furnace Co.
American Meter Co.
Arco Regulators, Inc.
Atlas Valve Co.
Automatic Valve Control

VALVES, Regulating (Cont'd)
Bailey Meter Co.
Bastian-Blessing Co.
Belfield Co.
Boylston Co.
Boiler Room Equipment
Bristol Co.
Brown Inst. Co.
Cash Co.
Cochrane Corp.
Connelly Iron Sponge
Consol. Ashcroft Hancock
Davis Reg. Co.
Defender Automatic Reg.
D'Este Co.
Dockson Co.
Electromatic Corp.
Fisher Governor Co.
Ford Reg. Valve Co.
Foster Engg. Co.
Foxboro Co.
Friez & Sons
Fulton Sylphon Co.
General Controls Co.
Hagan Corp.
Hanlon-Waters, Inc.
Hannifin Mfg. Co.
Illinois Eng. Co.
Jenkins Bros.
Kiely & Mueller
Klinfel Mfg. Co.
Lammert & Mann Co.
Leslie Co.
Linde Air Products Co.
Mason-Neilan Regulator
McAlear Mfg. Co.
National Airoil Burner
Natural Gas Equipment
Northern Equipment Co.
Partlow Corp.
Powers Regulator Co.
Republic Flow Meters
Robertshaw Thermostat
Ruggles-Klingemann
Schade Valve Mfg. Co.
Spence Engineering Co.
Tagliabue Mfg. Co.
Taylor Inst. Cos.
Vaughn-G E Witt
Victor Equipment Co.
Wilgus Manufacturing

VALVES, Safety Fuel Shut-off
American Meter Co.
Askania Regulator Co.
Atlas Valve Co.
Automatic Products Co.
Automatic Switch Co.
Bristol Co.
Brown Inst. Co.
Cash Co.
Davis Reg. Co.
D'Este Co.
Detroit Lubricator Co.
Eclipse Fuel Engg. Co.

VALVES, Safety Fuel Shut-off (Cont'd)
Friez & Sons
Fulton Sylphon Co.
General Combustion Corp.
General Controls Co.
Hagan Corp.
Hanlon-Waters, Inc.
Mason-Neilan Regulator
McAlear Mfg. Co.
McDonnell & Miller
Milwaukee Gas Specialty
National Airoil Burner
Natural Gas Equipment
Partlow Corp.
Payne Furnace & Supply
Penn Electric Switch
Preferred Utilities Mfg.
Ruggles-Klingemann
Spence Engineering Co.
Spencer Thermostat Co.
Tagliabue Mfg. Co.
Viking Instrument Co.
Wilgus Manufacturing

VALVES, Solenoid
Atkins & Co.
Atlas Valve Co.
Automatic Products Co.
Automatic Switch Co.
Barber-Coleman Co.
Brown Inst. Co.
Cutler-Hammer, Inc.
Davis Reg. Co.
Detroit Lubricator Co.
Electric Valve Mfg. Co.
Electrimatic Corp.
Foxboro Co.
Frick Co.
Friez & Sons
General Controls Co.
Gen. Elec. Co.
General Sales & Prod.
Guardian Elec. Mfg.
Hagan Corp.
Hannifin Mfg. Co.
Hays Corp.
Hook & Ackerman
Hunt & Co.
Leslie Co.
Magnatrol Valve Corp.
McDonnell & Miller
Northern Equip. Co.
Partlow Corp.
Penn Electric Switch
Perfex Corp.
Refrigerating Spec. Co.
Ross Operating Valve
Ruggles-Klingemann
Schade Valve Mfg. Co.
Spence Engineering Co.
Sterling Eng. Co.
Supreme Elec. Prods.
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VALVES Thermostat (See Thermostats)

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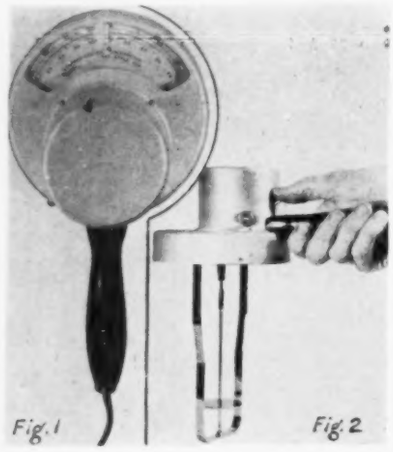

This illustration shows (Fig. 1) top and (Fig. 2) side view of standard model. For laboratory use, handle is removed from metal core which may be clamped in a ring stand.

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Central Scientific Co.
Chicago Apparatus Co.
Commercial Engg. Labs.
Impact Register Co.
RCA Manufacturing Co.
Ruska & Co.

VIBROMETERS
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American Inst. Co.
Ballantine Labs.
Electrical Research Prod.
Electrocon Corp.
Heiland Research Corp.
Potter Co.
Ruska & Co.
Suter, Alfred
Televiso Co.

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Commercial Engg. Labs.
Ruska & Co.

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Precision Scientific Co.
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Scientific Glass App.
Tagliabue Mfg. Co., C. J.
Thomas Co., Arthur H.

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Brookfield Eng. Labs.

VISCOSIMETERS, Engler
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Boekel & Co.
Central Scientific Co.
Humboldt Mfg. Co.
Precision Scientific Co.
Ruehfel Co.

VISCOSIMETERS, Fenske
American Inst. Co.

VISCOSIMETERS Ford (For Paint)
Central Scientific Co.
Eimer & Amend
Scientific Inst. Co.

VISCOSIMETERS, Hoepler
Central Scientific Co.
Fish-Schurman Co.

VISCOSIMETERS, Kinematic
Eimer & Amend

VISCOSIMETERS, MacMichael
Eimer & Amend

VISCOSIMETERS, Recording
Binckley, G. S.
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Esterline-Angus Co.

VISCOSIMETERS, Redwood
American Inst. Co.
Ruehfel Co.

VISCOSIMETERS, Saybolt
American Inst. Co.
Boekel & Co.
Central Scientific Co.
Corning Glass Works
Humboldt Mfg. Co.
Kimble Glass Co.
Precision Scientific Co.
Ruehfel Co.
Tagliabue Mfg. Co.
Zuhr, Inc., Henry

VISCOSIMETERS, Scott
Boekel & Co.
Central Scientific Co.
Precision Scientific Co.
Ruehfel Co.

VISCOSIMETERS, Stormer
Central Scientific Co.
Industro-Scientific Co.
Thomas Co., Arthur H.

VISCOSIMETERS, Ubbelohde
American Inst. Co.
Central Scientific Co.
Fish-Schurman Co.

VISCOSIMETERS, Zahn
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VISCOSITY REGULATORS (See Controllers, Automatic, Viscosity)

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Allen Elec. & Equip.
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De Jur-Amsco Corp.
General Elec. Co.
Hickok Elec. Inst. Co.
RCA Manufacturing Co.
Reliance Instrument Co.

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Welch Mfg. Co.

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General Electric Co.

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Ideal Commutator Dresser
Roller-Smith Co.
Sola Electric Co.
United Transformer Corp.

VOLTAGE DETECTORS (See Detectors, Voltage)

VOLTAGE DIVIDERS, Radio Frequency (See Dividers, Voltage)

VOLTAGE, HIGH (above 2300 volts) **Indicators**
General Elec. Co.
General Physical Lab.
Ideal Commutator Dresser
Rawson Electrical Inst.
Roller-Smith Co.
Sensitive Research Inst.
Shallcross Mfg .Co.
Triplett Electrical Inst.
Weston Elec. Inst. Corp.

VOLTAGE, HIGH (above 2300 volts) **Measuring Devices**
Associated Research
General Elec. Co.
International Resistance
Roller-Smith Co.
Sensitive Research Inst.
Westinghouse Elec. & Mfg.
Westinghouse X-Ray Co.
Weston Elec. Inst. Corp.

VOLTAGE, HIGH (above 2300 volts) **Testing Devices**
American Transformer
Associated Research
General Elec. Co.
Ideal Commutator Dresser
International Resistance
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Raytheon Mfg. Co.
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States Co.
Superior Elec. Co.
United Transformer Corp.
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VOLTAGE REGULATORS (See Regulators, Automatic, Voltage)

VOLT-AMMETERS
Esterline-Angus Co.
Rawson Electrical Inst.
Roller-Smith Co.
Sensitive Research Inst.
Therm-Electric Meters Co.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

VOLTMETERS, Contact Making
Burton-Rogers Co.
Electronic Laboratory
Electric Tachometer Corp.
Engineering Labs., Inc.
Esterline-Angus Co.
Ferranti Electric, Inc.
General Electric Co.
Geophysical Instrument Co.
Hickok Electrical Inst.
Reliance Instrument Co.
Roller-Smith Co.
Ruska & Co., Inc.
Weston Electrical Inst.

VOLTMETERS, Electrostatic
Cambridge Inst. Co.
Ferranti Electric, Inc.
General Elec. Co.
Hathaway Inst. Co.
Rawson Electrical Inst.

VOLTMETERS, Indicating
Ballantine Labs.
Burton-Rogers Co.
Clough-Brengle Co.
Columbia Elec. Mfg.
De Jur-Amsco Corp.
General Elec. Co.
Hickok Elec. Inst. Co.
Niagara Electrical Inst.
Norton Electrical Inst.
Precision Apparatus Corp.
Radio City Products Co.
Rawson Electrical Inst.
RCA Manufacturing Co.
Roller-Smith Co.
Sensitive Research Inst.
Simpson Elec. Co.
Triumph Mfg. Co.
Welch Mfg. Co.
Westinghouse Elec. & Mfg.
Weston Elec. Inst Corp.

VOLTMETERS, Megohm
Associated Research
Jackson Electrical Inst.
Rawson Electrical Inst.
RCA Manufacturing Co.
Sensitive Research Inst.
Shallcross Mfg. Co.
Sticht & Co.
Televiso Co.
Welch Mfg. Co.
Weston Elec. Inst. Corp.

VOLTMETERS, Micro
Cambridge Inst. Co.
De Jur-Amsco Corp.
Hickok Elec. Inst. Co.
Microvolts, Inc.
Rawson Electrical Inst.
Sensitive Research Inst.
Supreme Instruments

VOLTMENTERS, Micro (Cont'd)
Televiso Co.
Triplett Electrical Inst.
Weston Elec. Inst. Corp.
Wheelco Inst. Co.

VOLTMETERS, Micro, Radio Frequency
Ferris Inst. Corp.

VOLTMETERS, Millivoltmeters
Allen Elec. & Equip.
Ballantine Labs.
Bristol Co.
Burton-Rogers Co.
Cambridge Inst. Co.
De Jur-Amsco Corp.
Engelhard, Chas.
Esterline-Angus Co.
Etna Elec. Works
General Elec. Co.
Hickok Elec. Inst. Co.
Radio City Products Co.
Rawson Electrical Inst.
Roller-Smith Co.
Sensitive Research Inst.
Simpson Elec. Co.
Southw'n Electronics Labs
Tagliabue Mfg. Co.
Thwing-Albert Inst. Co.
Triplett Electrical Inst.
Welch Mfg. Co.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.
Wheelco Inst. Co.

VOLTMETERS, Oxide Rectifier
Clough-Brengle Co.
De Jur-Amsco Corp.
General Elec. Co.
General Radio Co.
Hickok Elec. Inst. Co.
Radio City Products Co.
Roller-Smith Co.
Simpson Elec. Co.
Supreme Instruments.
Triplett Electrical Inst.
Triumph Mfg. Co.
Westinghouse Elec. & Mfg.
Weston Elec. Inst. Corp.

VOLTMETERS, Peak
Clough-Brengle Co.
General Elec. Co.
Hickok Elec. Inst. Co.
RCA Manufacturing Co.
Sensitive Research Inst.

VOLTMETERS, Recording
Bristol Co.
Cambridge Inst. Co.
Engelhard, Chas.
Esterline-Angus Co.
General Elec. Co.
Leeds & Northrup Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg.

VOLTMETERS, Thermionic Rectifier
Andrew, Victor J.
Cambridge Inst. Co.
General Radio Co.
Microvolts, Inc.

VOLTMETERS, Thermo
Am. Elec. Sales Co.
Cambridge Inst. Co.
De Jur-Amsco Corp.
Etna Elec. Works
General Elec. Co.
Hickok Elec. Inst. Co.
Rawson Electrical Inst.
Sensitive Research Inst.
Triplett Electrical Inst.
Weston Elec. Inst. Corp.
Wheelco Inst. Co.

VOLTMETERS, Vacuum Tube
Andrew, Victor J.
Ballantine Labs.
Cambridge Inst. Co.
Clough-Brengle Co.
Fisher Scientific Co.
General Elec. Co.
General Radio Co.
Jones-Ormo Co.
Luxtrol Co., Inc.
Microvolts, Inc.
Radio City Products Co.
Reliance Instrument Co.
Televiso Co.
Triplett Electrical Inst.
Triumph Mfg. Co.
Weston Elec. Inst. Corp.
Shallcross Mfg. Co.

VOLT-OHMMETERS
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De Jur-Amsco Corp.
Hickok Elec. Inst. Co.
Jackson Electrical Inst.
Precision Apparatus Corp.
Radio City Products Co.
Rawson Electrical Inst.
RCA Manufacturing Co.
Roller-Smith Co.
Sensitive Research Inst.
Shallcross Mfg. Co.
Simpson Elec. Co.
Triplett Electrical Inst.
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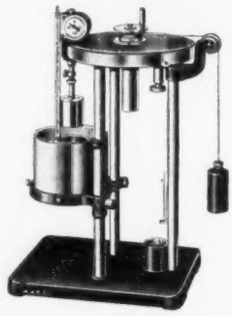

STORMER VISCOSIMETER. For determining viscosity by measurement of the time required for a definite number of revolutions of a rotor immersed in a sample placed in the test cup and maintained at a desired temperature and driven by a definite weight. Readings are independent of specific gravity and give relative viscosity. Centipoise readings can be determined by a calibration table. See, *"Chemical Engineers' Handbook"*, John H. Perry, Editor (New York, 1934), p. 1273.

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INDEX is concluded on page 64

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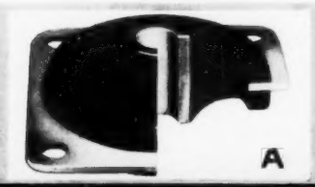
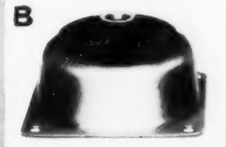


A. ¼ Section of Square Plate Form Mounting.
B. Plate Form Mounting in stamped holder.
C. Square Plate Form Mounting.



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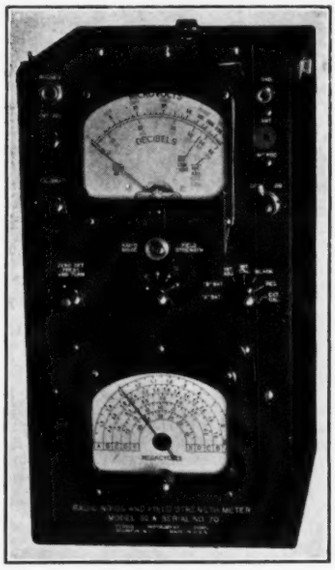

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Electrocon Corp., 6 Varick St., New York, N. Y.
Vibration measuring instruments & equipment for dynamic balancing of rotating machines

Electronic Design Corp., 164 No. May St., Chicago, Ill.
Radio test instruments

Electronic Laboratory, 306 S. Edinburgh Ave., Los Angeles, Calif.
Photo-electric instruments; also photoconductive cells.

Electronic Products Co., St. Charles, Ill.
Electronic devices

Electronic Research Laboratory, Niles Center, Illinois
Color analysis apparatus

Electrons, Inc. of Delaware, 127 Sussex Ave., Newark, N. J.
Gas-filled & grid-control rectifier tubes

Elgin National Watch Co., Elgin, Ill.
Watches, clocks, aircraft instruments

Ellison Draft Gage Co., 214 West Kenzie St., Chicago, Ill.
Manometers, draft gages, orsats

Elsbert Mfg. Co., Inc., 353 West Grand Ave., Chicago, Ill.
Remote control fractional horsepower motors

Emerson Apparatus Co., 171 Tremont St., Melrose, Mass.
Calorimeters

Emery Co., A. H., 682 Main St., Stamford, Conn.
Bourdon gages

E-Nam Corporation, 45 E. 17 St., New York, N. Y.
Fine enameled copper wire

Engel, Inc., H. C. M., P. O. Box 233, Sidney, N. Y.
Small drills, small turned parts, millstones in sapphire and block grinding discs

Engelhard, Inc., Charles, 233 New Jersey R. R. Ave., Newark, N. J.
Industrial instruments

Engineering Laboratories, Inc., 705 Kennedy Bldg., Tulsa, Okla.
Seismic exploration equipment, vibration detectors, petroleum engineering devices, signalling equipment

Eppley Laboratory Inc., 12 Sheffield Ave., Newport, R. I.
Thermopiles, pyrheliometers & standard cells for both industrial & laboratory use

Ermastat Co., 1825-39 Wylie St., Philadelphia, Pa.
Electric motor overload protectors

Ess Instrument Co., 31 Irving Place, New York, N. Y.
Combustion indicators & recorders, visual & electric eye smoke indicators, flame failure alarms, sensitive relays & special electric eye indicators

Esterline-Angus Co., Inc., P. O. Box 596, Indianapolis, Ind.
Graphic recording & contact-making electrical instruments, time, speed, condensate purity, pressure & vacuum recorders, telemeters & portable current transformers

Etna Electric Works, 410 East 15th St., New York, N. Y.
Electrical instruments

Everson Mfg. Co., 214 W. Huron St., Chicago, Ill.
Chemical feeders

Exact Weight Scale Co., 944 West 5th Ave., Columbus, Ohio
Over-and-under weight scales & indicators for industrial purposes

F

Faicimey Instrument Corp., Watertown, N. Y.
Laboratory thermometers

Fairbanks, Morse & Co., 600 So. Michigan Ave., Chicago, Ill.
Scales

Falstrom Co., Main Ave. & D. L. & W. R. R., Passaic, N. J.
Steel instrument panels, panel board assemblies, cubicles, totally enclosed weather & vermin proof instrument enclosures & steel cabinets

Fassett Co., Inc., C. M., 209 North Wall St., Spokane, Wash.
Laboratory supplies

Fecker, J. W., 2016 Perrysville Ave., N. S., Pittsburgh, Pa.
Astronomical instruments

Federal Pneumatic Systems, Inc., 127 N. Dearborn St., Chicago, Ill.
Particle size classifiers

Federal Products Corp., 1144 Eddy St., Providence, R. I.
Precision measuring instruments

Fee and Stemwedel, Inc., 4949 North Pulaski Rd., Chicago, Ill.
Dial type thermometers, barometers, humidity indicators & allied products, field glasses & binoculars

Fenwal, Inc., 3 Main St., Ashland, Mass.
Industrial thermostats

Ferner Co., R. Y., 131 State St., Boston, Mass.
Precision instruments

Ferranti Electric, Inc., 30 Rockefeller Plaza, New York, N. Y.
Electrical instruments

Ferris Instrument Corp., Boonton, N. J.
Laboratory & production testing equipment, radio noise & field strength meters & special electrical instruments

Fidelity Machine Co., 3906 Frankfort Ave., Philadelphia, Pa.
Abrasion testers

Fischer & Porter Co., 128 West Penn St., Germantown, Philadelphia, Pa.
Rotameters, sight flow meters, precision glass tubes of any shape including square, oval, cylindrical, tapered.

Fish-Schurman Corp., 250 East 43rd St., New York, N. Y.
Scientific instruments, optical, technical & scientific glassware & porcelain

Fisher Governor Co., Marshalltown, Iowa
Motor control valves & regulators

Fisher Scientific Co., 711 Forbes St., Pittsburgh, Pa.
Standard & special equipment & instruments for chemical, biological & metallurgical laboratories

Fleischhauer & Son, Frank, 89-36 187 Place, Hollis, L. I., N. Y.
Thermometers & hydrometers

Fluid Meters, Inc., 44 Wall St., Room 1101, New York, N. Y.
Positive displacement meters, 1/10 to 8 gallons per hour with gravity pressures

Ford Meter Box Co., Wabash, Indiana
Water meter testers

Ford Motor Company, 3674 Schaefer Rd., Dearborn, Mich.
Johansson gage blocks & accessories such as parallels, adjustable holders, scribers, straight edges, center points, sine bars

Ford Regulator Valve Co., 403 Broome St., New York, N. Y.
Regulating valves

Foster Engineering Co., 109 Monroe St., Newark, N. J.
Control valves

Foxboro Co., 46 Neponset Ave., Foxboro, Mass.
Indicating, recording & controlling instruments for pressure, temperature, humidity, level & flow

Frick Co., Inc., Waynesboro, Pa.
Float valve controls & electric controls, refrigerating & air conditioning machinery

Fried & Lustig, Inc., 31 Union Square, New York, N. Y.
Thermometers

Friez & Sons, Julien P., Baltimore St. & Central Ave., Baltimore, Md.
Temperature & humidity controls, gas & stoker controls, damper motors, electrical relays, temperature & humidity indicators & recorders, psychrometers, draft gages, anemometers, CO_2 analyzers

Frober-Faybor Co., 4612 Prospect Ave., Cleveland, Ohio
Photoelectric colorimeters

Fuess, Inc., R., 39 West 60th St., New York, N. Y.
Scientific instruments

Fulton Sylphon Co., Knoxville, Tenn.
Temperature & pressure regulators, sylphon bellows; thermostat assemblies; diesel controls; automobile thermostats; air conditioning controls

Furnas Electric Co., 811 South 72nd St., West Allis, Wis.
Pressure controls

G

Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.
Physical & scientific instruments

Gas Appliance Specialties Co., 57th St., bet. Northern Blvd. & 32nd Ave., Woodside, New York, N. Y.
Gas regulators

Gauthier, Donat A., 7408 Poe Ave., Detroit, Mich.
Gasoline measuring devices & automobile service station testers

Geier & Bluhm Inc., 607 River St., Troy, N. Y.
Mechanical devices & spirit level vials

Genales, Andrew, 29 Second Ave., Nyack, N. Y.
Toolroom test indicators

General Biological Supply House, Inc., 761 East 69th Pl., Chicago, Ill.
Biological laboratory supplies

General Combustion Corp., 2218 W. Lake St., Chicago, Ill.
Combustion equipment

General Controls Co., 1370 Harrison, San Francisco, Calif.
Control valves

General Electric Co., 1 River Rd., Schenectady, N. Y.
Electrical instruments & meters

General Electric Co., Lamp Dept., Nela Park, Cleveland, Ohio
Lighting sources

General Electric X-Ray Corp., 2012 Jackson Blvd., Chicago, Ill.
Medical, dental & industrial X-ray apparatus, accessories & suppliers

General Engg. & Model Works, 421 N. Braddock Ave., Pittsburgh, Pa.
Gages & precision measuring instruments for checking threaded tubular products

General Physical Laboratory, 509 Fifth Ave., New York, N. Y.
Electronic apparatus

General Radio Co., 30 State St., Cambridge, Mass.
Radio & electrical measuring instruments for laboratory & industrial use: stroboscopes, noise measuring equipment, measuring & test equipment for electrical communication systems

General Regulator Corp., 165 Broadway, New York, N. Y.
Combustion, draft, liquid level & pressure controls

General Sales & Products Corp., 45 Mohawk St., Cohoes, N. Y.
Shut-off valves

General Scientific Corp., 4829 So. Kedzie Ave., Chicago, Ill.
Lenses & photoelectric cells

General Television Corp., 70 Brookline Ave., Boston, Mass.
Ionization vacuum gages

Geophysical Instrument Co., 1315 Half St., S. E., Washington, D. C.
Instruments & accessories for prospecting for oil, minerals, water, bedrock; also equipment for making measurements in wells

Gilmore, E. R., Box 5718, Homewood Sta., Pittsburgh, Pa.
Gas leak stethoscopes

Gisholt Machine Co., Madison, Wis.
Static & dynamic balancing machines

Glass Engraving Co., 3604-3606 Park Ave., New York, N. Y.
Glass engraving

Gleason-Avery, Inc., 27 Clark, Auburn, N. Y.
Furnace controls

Globe Phone Mfg. Corp., Reading, Mass.
Pipe locating equipment, leaky valve locators, hearing aids, secret phone or listening equipment for government investigating agencies

Globe Tool & Engg. Co., 410 Davis Ave., Dayton, Ohio
Dynamic balancing equipment

Glogau & Co., 1632 Rand McNally Bldg., Chicago, Ill.
Calipers

G-M Laboratories, Inc., 1731 Belmont Ave., Chicago, Ill.
Photoelectric cells, photoelectric relays, slide wire rheostats, galvanometers, laboratory stands & clamps

G. M. Manufacturing Co., 180 Centre St., New York, N. Y.
Thermometers, hydrometers, psychrometers, hygrometers

G. M. Manufacturing Co., Inc., 43-10 - 21st St., Long Island City, N. Y.
Tire pressure gages & engine compression indicators

Goerz American Optical Co., C. P., 317 East 34th St., New York, N. Y.
Photographic lenses & accessories

Goodrich Co., B. F., 450 South Main St., Akron, Ohio
Vibration absorbers

Gordon Co., Claud S., 1524 S. Western Ave., Chicago, Ill.
High temperature equipment accessories, such as thermocouples, thermocouple wire, lead wire, insulators

Gorrell & Gorrell, Chicago Heights, Ill.
Equipment for biological & psychological work

Gotham Instrument Co., 127 Spring St., New York, N. Y.
Indicating, dial & recording thermometers

Gotham Scientific Co., 106 Water St., New York, N. Y.
Laboratory supplies

Gow-Mac Instrument Co., 20 Washington Pl., Newark, N. J.
Thermal conductivity gas analyzers & gas analysis cells

Gray Instrument Co., 64½ W. Johnson St., Philadelphia, Pa.
Scientific instruments

Green, Arthur R., 284 Harris Ave., Needham, Mass.
Paper plant test instruments

Green, Henry J., 1191 Bedford Ave., Brooklyn, N. Y.
Meteorological instruments

Greenfield Tap & Die Corp., Greenfield, Mass.
Machine shop gages

Griebel Instrument Co., Inc., 42 River St., Carbondale, Pa.
Thermometers, hydrometers, chemical & laboratory glassware

Griner Co., A. J., 417 East 13th St., Kansas City, Mo.
Laboratory supplies

Grove Regulator Co., 1729 Poplar St., Oakland, Calif.
Pump governors, pressure reducing & back pressure regulators for gas or liquid pressures to 6000 lbs.

Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago, Ill.
A-c. and d-c. relays

Gump Co., B. F., 435 S. Clinton St., Chicago, Ill.
Scales

Gurley, W. & L. E., 514 Fulton St., Troy, N. Y.
Surveying & allied engineering instruments, paper testing & aeronautical navigation instruments & standard weights & measures

H

Hagan Corp., 600 Bowman Bldg., Pittsburgh, Pa.
Combustion control equipment

Haines Gauge Co., 119 South 4th St., Philadelphia, Pa.
Dial micrometer gage

Hall-Jorson Co., 4500 Ravenswood Ave., Chicago, Ill.
Laboratory transformers

Halliburton Oil Well Cementing Co., Duncan, Okla.
Oil well surveying instruments

Hamilton Mfg. Co., Two Rivers, Wis.
Laboratory furniture

Hanlon-Waters, Inc., Box 1559, Tulsa, Okla.
Pressure & level controls, time cycle controllers

Hannifin Mfg. Co., 621 So. Kolmer Ave., Chicago, Ill.
Valve operating devices

Hanovia Chemical & Mfg. Co., 90 Chestnut St., Newark, N. J.
Quartz mercury arc lamps

Hardwick, Hindle, Inc., 40 Hermon St., Newark, N. J.
Resistors

Hart Manufacturing Co., 110 Bartholomew Ave., Hartford, Conn.
Thermostats, remote control switches, magnetic relays, heater switches, motor control switches, mercury tube relays

Hart Mfg. Co., R. E., 416 Ward Bldg., Battle Creek, Mich.
Production counters

Hasler-Tel Co., 30 Vesey St., New York, N. Y.
Speed indicators, portable, chronometric

Hathaway Instrument Co., 517 S. University Blvd., Denver, Colo.
Instruments & apparatus for electrical & mechanical measurements & control.

Hayes Scientific Appliances, 202 N. Broadway, Urbana, Ill.
Scientific instruments

Hays Corp., P. O. Box 299, Michigan City, Ind.
Combustion instruments & automatic combustion controls

Hays Laboratories, Box 752, Pawtucket, R. I.
Colorimeters

H-B Electric Co., Inc., 2501 N. Broad St., Philadelphia, Pa.
Mercury tube relays

H-B Instrument Co., Inc., 2501 N. Broad St., Philadelphia, Pa.
Thermometers & hydrometers, remote control equipment

HD Electric Co., 100 W. Monroe St., Chicago, Ill.
Split core ammeters

Hebler Co., W. O., Central at Long Ave., Hillside, N. J.
Electrical gas analyzers

Heiland Research Corp., 700 Club Bldg., Denver, Colo.
Geophysical & industrial instruments

Heise Bourdon Tube Co., 275 Noble Ave., Bridgeport, Conn.
Bourdon tube devices

Hellige, Inc., 3718 Northern Blvd., Long Island City, N. Y.
Scientific instruments, laboratory & bacteriological supplies

Henderson & Co., H. B., East Liverpool, Ohio
Pyrometric cones

Henschel & Co., Inc., John, 105 E. 29th St., New York, N. Y.
Drawing instruments

Henszey Co., Watertown, Wis.
Feed water meters, flow indicators continuous blowdown, heat exchangers and boiler feed regulators. Also meters and flow indicators for corrosive chemicals

Heusser Instrument Mfg. Co., 134 West Second South St., Salt Lake City, Utah
Analytical balances

Hewlett-Packard Co., 367 Addison Ave., Palo Alto, California.
Electronic equipment

Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Electric indicating instruments

Hoffman Co., S. O., 835 Howard St., San Francisco, Calif.
Bolometers

Hoke, Inc., 122 Fifth Ave., New York, N. Y.
Regulators

Holz, Herman A., 116 West 14th St., New York, N. Y.
Testing machines

Hook & Ackerman, Inc., 349 Freeport, Aspinwall, Pittsburgh, Pa.
Solenoid valves

Hoskins Mfg. Co., 4445 Lawton Ave., Detroit, Mich.
Thermo-couples, heating elements, pyrometers & electric furnaces

Howard Clock Products, Inc., 256 Charles St., Waltham, Mass.
Observatory & seismological clocks.

Howe & French, Inc., 99 Broad St., Boston, Mass.
Laboratory supplies

Howe Scale Co., Rutland, Vt.
Scales

Huddleston, J. S. F., 104 Hanover St., Boston, Mass.
Thermometers

Humboldt Mfg. Co., 2014 N. Whipple St., Chicago, Ill.
Cement & concrete testers

Hunt & Son, C. B., Salem, Ohio
Valves & valve operating devices.

Hydraulic Press Co., Mount Gilead, Ohio
Pressure controls

Hy Ef Electrical Products Mfg. Co., 1515 West Pico, Los Angeles, Calif.
Automobile service station instruments

I

Ideal Commutator Dresser Co., Sycamore, Ill.
Insulation testers

Illinois Engineering Co., Racine Ave. & 20th Pl., Chicago, Ill.
Regulating valves

Illinois Testing Laboratories, Inc., 420 North La Salle St., Chicago, Ill.
Indicating pyrometers, resistance thermometers, pyrometer controllers, air velocity meters, metal detectors.

Impact Register Co., 315 So. Neil St., Champaign, Ill.
Instruments for determining and recording impacts received by railroad cars and riding qualities of railroad cars, automobiles

Improved Gauge Mfg. Co., 101-105 Canal St., Syracuse, N. Y.
Bourdon gages

Indicating Calipers Corp., 506 East 19th St., New York, N. Y.
Indicating calipers

Industrial Engineering Corp., Evansville, Ind.
Relays

Industrial Instrument Co., 2249 14th St., S. W., Akron, Ohio
Temperature, pressure & time cycle controllers, indicating & dial thermometers, diaphragm valves.

Industrial Instruments, Inc., 156 Culver Ave., Jersey City, N. J.
Electrical measuring & test equipment

Industro-Scientific Co., 340 So. Camac St., Philadelphia, Pa.
Valentine refractometers & PQ viscosimeters

Inferno Co., Box 1138, Shreveport, La.
Combustion instruments

Inspection Machinery Co., 5511 Euclid Ave., Cleveland, Ohio
Custom built automatic equipment for counting, gaging, weighing & electrical testing of small parts & devices, industrial electronic control devices

Instrument Resistors, Inc., 375 Main St., Little Falls, N. J.
Wire wound resistors

Instrument Specialties Co., Inc., 379 Main St., Little Falls, N. J.
Precision micrometer
Intercontinental Marketing Corp., 10 E. 40th St., New York, N. Y.
Photoelectric cells
International Business Machines Corp., 590 Madison Ave., New York, N. Y.
Scales & time instruments
International Equipment Co., 352 Western Ave., Boston, Mass.
Analytical centrifuges
International Filter Co., 325 W. 25th Place, Chicago, Ill.
Hydraulic measurement & control & chemical feeding & proportioning.
International Register Co., 25 South Throop St., Chicago, Ill.
Coin meters—timers for electric ranges & gas ovens.
International Resistance Co., 401 N. Broad St., Philadelphia, Pa.
Metallized & wirewound fixed & variable resistors including high voltage & high frequency types.

J

Jackson Electrical Instrument Co., 129 Wayne Ave., Dayton, Ohio
Radio testing equipment
Jacobs Bros. Co. Inc., 1 Main St., Brooklyn, N. Y.
Scales
Jaeger Watch Co., Inc., 304 East 45th St., New York, N. Y.
Automobile clocks, timepieces for aviation and marine, chronometric tachometers & true airspeed indicators
Jardur Import Co., 21 W. 19th St., New York, N. Y.
Chronographs & stop-watches
J B L Instrument Co., P. O. Box 135, Darby, Pa.
Rotary instrument switches, transformer tapping, railway signal gear, decade resistance boxes
J-B-T Instruments, Inc., 441 Chapel St., New Haven, Conn.
Electrical measuring & controlling instruments: pyrometers, thermocouples, selector switches, potentiometers, resistance thermometers, laboratory instruments
Jeffrey Mfg. Co., Columbus, Ohio
Weighting, feeding, batching & proportioning equipment
Jenkins Bros., 80 White St., New York, N. Y.
Regulating valves
Jensen Instrument Co., 624 East 4th St., Los Angeles, Calif.
High pressure manometer
Jerguson Gage & Valve Co., Mystic Ave. & Fellsway, Somerville, Mass.
Automatic shut-off valves
Johnson Service Co., 507 E. Michigan St., Milwaukee, Wisc.
Automatic temperature & humidity control for heating, cooling, ventilating, air conditioning & industrial processes
Johnson-Williams, Ltd., Box 8, Palo Alto, Calif.
Combustible gas indicators & alarm systems, portable & continuous, including accessories
Johnston & Jennings Co., 877 Addison Rd., Cleveland, Ohio
Oil meters
Johnston Manufacturing Co., 2823 E. Hennepin Ave., Minneapolis, Minn.
Furnace controls
Jones & Lamson Machine Co., Clinton & Whitmore Sts., Springfield, Vt.
Optical comparators
Jones Motrola Sales Co., 432 Fairfield Ave., Stamford, Conn.
Tachometers
Jones-Orme Co., 2233 University Ave., St. Paul, Minn.
Audio frequency standard signal generators, oscillators, laboratory amplifiers & special audio frequency laboratory equipment
Judson Governor Co., 38 Browns Race, Rochester, N. Y.
Governors

K

Kansas City Laboratory Supply Co., 1434 Wyandotte St., Kansas City, Mo.
Laboratory supplies
Karp Metal Products Co. Inc., 129 - 30th St., Brooklyn, N. Y.
Instrument panels
Keller Mfg. Co., G. P., 1388 South State St., Salt Lake City, Utah
Balances & weights of precision
Kelley-Koett Mfg. Co. Inc., Covington, Ky.
X-Ray apparatus
Kellogg Switchboard & Supply Co., Clearing Station, Chicago, Ill.
Relays
Kenyon Instrument Co., Inc., 273 New York Ave., Huntington, L. I., N. Y.
Airport & marine instruments
Kern Co., 136 Liberty St., New York, N. Y.
Surveying & astronomical instruments
Kessling Thermometer Co., E., 682-684 Jamaica Ave., Brooklyn, N. Y.
Thermometers
Keuffel & Esser Co., Adams & Third Sts., Hoboken, N. J.
Surveying instruments
Kewaunee Mfg. Co., 106 Lincoln St., Kewaunee, Wis.
Laboratory furniture
Kieley & Mueller, Inc., 40 W. 13th St., New York, N. Y.
Pressure regulating & flow control devices
Kimball Co., W. W., 420 Kimball Bldg., Chicago, Ill.
Laboratory furniture
Kimble Glass Co., Vineland, N. J.
Glass apparatus, glass tubing, thermometers, hydrometers
Kingsbury Machine Works, Inc., 4316 Tackawanna St., Philadelphia, Pa.
Thrust meters
King-Seeley Corp., 302 Second St., Ann Arbor, Mich.
Fuel level, oil pressure & temperature gages; also ammeters & voltmeters
Klett Mfg. Co., 179 E. 87th St., New York, N. Y.
Colorimeters
Klingerit, Inc., 16 Hudson St., New York, N. Y.
Liquid level gages
Klinfel Mfg. Co., 2641 W. Harrison St., Chicago, Ill.
Regulating valves
Knowles Scale Works, Lowell, Mass.
Platform, counter & beam scales
Kolesch & Co., 138 Fulton St., New York, N. Y.
Surveying instruments
Kollmorgen Optical Co., 767 Wythe Ave., Brooklyn, N. Y.
Astronomical & optical instruments
Kollsman Instrument Co. Inc., 8008 - 45th Ave., Elmhurst, Long Island, N. Y.
Precision instruments for aircraft
Kron Co., Bridgeport, Conn.
Scales
Krouse Testing Machine Co., 101 E. Dominion Blvd., Columbus, Ohio
Fatigue testing machines
Kurman Electric Co. Inc., 241 Lafayette St., New York, N. Y.
Relays, electrical test equipment, hearing devices

L

L. A. B. Corp., P. O. Box 162, Summit, N. J.
Special instruments
Laboratory Construction Co., 1113-15 Holmes St., Kansas City, Mo.
Laboratory furniture & apparatus
Laboratory Furniture Co., Inc., 37-18 Northern Blvd., Long Island City, N. Y.
Laboratory furniture
Laboratory Materials Co., 7319 Vincennes Ave., Chicago, Ill.
Laboratory supplies
Lambert Meter Co., Inc., Plainfield, N. J.
Gas meters
Lammert & Mann Co., 260 N. Woods St., Chicago, Ill.
Flow regulators & valves
LaMotte Chemical Products Co., McCormick Bldg., Baltimore, Md.
Hydrogen ion apparatus
Lampkin Laboratories, Bradenton, Fla.
Radio-frequency meters
Landis & Gyr, Inc., 104 Fifth Ave., New York, N. Y.
Electric integrating meters; indicating & graphic demand meters for KW, KVA, reactive; prepayment meters; totalizing & remote; time switches; motor wound escapement or synchronous motor types with astronomic dials; miniature ball bearings
Lantz-Phelps Corp., 420 Linden Ave., Dayton, Ohio
Automotive test instruments
La Pine & Co., Arthur S., 114 W. Hubbard St., Chicago, Ill.
Laboratory supplies
Leach Relay Co., 5915 Avalon Blvd., Los Angeles, Calif.
Relays
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia, Pa.
Electrical measuring instruments for both laboratory & plant. For laboratory: bridges, galvanometers, potentiometers, photometric equipment, test sets & standards. For plant: indicators, recorders & controllers for chemical concentration, CO_2, current, electrolytic conductivity, frequency, gas analysis, humidity, Kw, Rkva, light, electrical load, pH, pressure, pyrometry, radiation, smoke density, speed, temperature, voltage. Speedomax Recorders, Centrimax Flowmeters & Metermax Combustion control Systems
Leitz, Inc., E., 730 Fifth Ave., New York, N. Y.
Optical instruments
Leslie Co., Lyndhurst, N. J.
Pressure reducing valves, pump governors, temperature regulators
Leupold, Volpel & Co., 425 N. E. 70th Ave., Portland, Oregon
Recorders & indicators, for irrigation, power, waterworks, sewerage. Equipment for hydraulic laboratories. Snow-rain recorders, hydrographic accessories, transits, levels
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Portable pyrometers, potentiometers, resistance thermometers & other electrical temperature measuring devices
Lincoln Meter Co., Springfield, Ill.
Thermal ampere demand & watt demand meters, indicating & graphic
Lindberg Engineering Co., 221 North Laflin St., Chicago, Ill.
Electric power input controls
Link Engineering & Mfg. Co., 1054 W. Baltimore Ave., Detroit, Mich.
Spring testers
Lipman Engineering Co., 415 Van Braam St., Pittsburgh, Pa.
Photoelectric counters
Liquidometer Corp., 36-16 Skillman Ave., Long Island City, N. Y.
Liquid level gages
Littelfuse, Inc., 4757 Ravenswood Ave., Chicago, Ill.
Low range precision fuses & fuse mountings
Loewenberg, F., 10 East 40th St., New York, N. Y.
Photo-electric elements, photometers, electronic timing devices, photo-electric colorimeters, photo-electric exposure meters, densitometers
Lord Mfg. Co., 1316 Holland Ave., Erie, Pa.
Vibration proof mountings & flexible couplings for practical horsepower motors
Luers, J. Milton, 12 Pine St., Mt. Clemens, Mich.
Timers
Lufkin Rule Co., Saginaw, Mich.
Precision tools & measuring tapes
Lumenite Electric Co., 37 West Van Buren St., Chicago, Ill.
Photoelectric controls
Lundquist Tool & Mfg. Co., 57 Jackson St., Worcester, Mass.
Ammeters
Lux Clock Mfg. Co., Inc., 95 Johnson St., Waterbury, Conn.
Automatic timers & clock mechanisms
Luxtrol Co., Inc., 54 West 21st St., New York, N. Y.
Photoelectric apparatus

M

Macalaster Bicknell Co., 171 Washington St., Cambridge, Mass.
Laboratory supplies
Macbeth Daylighting Corp., 227 West 17th St., New York, N. Y.
Daylight Lamps for titration & color matching
Machlett & Son, E., 220 East 23rd St., New York, N. Y.
Laboratory apparatus & supplies
Magnaflux Corp., 605 W. Washington St., Chicago, Ill.
Magnetic inspectors
Magnatrol Valve Corp., 52 Beekman St., New York, N. Y.
Valves
Magnavox Co., Inc., Fort Wayne, Indiana
Electrolytic capacitors
Magnetic Analysis Corp., 42-44 12th St., Long Island City, N. Y.
Magnetic inspectors for uniform cross-sectional steel
Magnetic Gauge Co., 60 E. Bartges St., Akron, Ohio
Continuous gages, sheet & strip
Marine Compass Co., Bryantville, Mass.
Marine instruments
Marsh Corp., Jas. P., 2073 Southport Ave., Chicago, Ill.
Indicating gages, recording gages, dial thermometers, recording thermometers, refrigeration service instruments, temperature controlling systems, valves for heating systems
Marston Co., C. A., 506 Washington St., Braintree, Mass.
Time study instruments
Martindale Electric Co., Box 2669, Lakewood Branch, Cleveland, Ohio
Insulation testers
Martin-Decker Corp., P. O. Box 571, Long Beach, Calif.
Torque gages & pull rod dynamometers
Mason-Neilan Regulator Co., 1190 Adams St., Boston, Mass.
Industrial control equipment for pressure temperature, flow, liquid level, combustion & ratio: diaphragm control valves; pressure & vacuum regulators; level controllers; pump speed governors; pump pressure regulators; pipe strainers
Master Optical Co., 19 West 36th St., New York, N. Y.
Lenses, prisms & optical parts
McAlear Mfg. Co., 1901 S. Western Ave., Chicago, Ill.
Manual & automatic controls for air, oil gas, steam, chemicals, pure food, acid & alkali
McCord Radiator & Mfg. Co., 2585 E. Grand Ave., Detroit, Mich.
Liquid meters for low flows
McCorkle Co., D. H., 6th & Bancroft Way, Berkeley, Calif.
Thermostats & electric gas valves
McDonnell & Miller, Room 1316, Wrigley Bldg., Chicago, Ill.
Boiler controls
McDonnell Odometer Co., 3501 So. Kedzie Ave., Chicago, Ill.
Counters
McFarlin Co., 29 West Marion Ave., Youngstown, Ohio
Leak detectors
McNab of Bridgeport, Inc., Bridgeport, Conn.
Marine appliances, torsionmeters, salinity indicators, revolution counters
McNeill Engineering Equipment Co., T. W., 4057 West Van Buren St., Chicago, Ill.
Smoke alarms
Measured Time, Inc., La Porte, Ind.
Timers

Meldrum-Gabrielson Corp., 601 W. Fayette St., Syracuse, N. Y.
Snap gages

Mercoid Corp., 4201 Belmont Ave., Chicago, Ill.
Automatic controls for heating, refrigeration, air conditioning, & various industrial applications

Mercon Regulator Co., 2357 N. 29th St., Milwaukee, Wisc.
Power plant specialties in regulation of pressure, level, rate of flow, proportioning & temperature

Meriam Co., 1955 W. 112th St., Cleveland, Ohio
Manometers, draft gages, indicating flow meters for steam, oil, gas, air, water, tank liquid level gages

Merkle-Korff Gear Co., 214 North Morgan St., Chicago, Ill.
Motorized speed reducers: induction, synchronous, reversing, d-c., universal motors

Merrick Scale Mfg. Co., Autumn St., Passaic, N. J.
Automatic continuous weighing machines

Merritt Engg. & Sales Co., Inc., 120 So. Niagara St., Lockport, N. Y.
Consistency controls

Micro Switch Corp., Spring St., Freeport, Illinois
Snap action switches

Microvolts, Inc., 212 Harrison St., Boonton, N. J.
Radio-frequency testing & measuring devices

Miles Reproducer Co., 812 Broadway, New York, N. Y.
Microphones, sound recorders, amplifiers for industry.

Miller Co., B. F., P. O. Box 455, Trenton, N. J.
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Millers Falls Co., Greenfield, Mass.
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Million Radio & Television, 685 West Ohio St., Chicago, Ill.
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Milwaukee Gas Specialty Co., 2025 W. Clybourn, Milwaukee, Wis.
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Mine & Smelter Supply Co., 1422-17th St., Denver, Colo.
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Minneapolis Elec. & Construction Co., 80 South 12th St., Minneapolis, Minn.
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Meter Devices Co., 1001 Prospect Ave., S. W., Canton, Ohio
Electrical test devices

Meyer Governor Co., 284 Baker Bldg., Minneapolis, Minn.
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Misener Mfg. Co., Inc., 300 E. Washington St., Syracuse, N. Y.
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Moeller Instrument Co., 132nd St. & 89th Ave., Richmond Hill, N. Y.
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Moisture Register Co., 1029 N. Sycamore Ave., Los Angeles, Calif.
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Morse Twist Drill & Machine Co., New Bedford, Mass.
Gear testers

Munsell Color Co., Inc., 10 E. Franklin St., Baltimore, Md.
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Muter Company, 1255 S. Michigan Ave., Chicago, Ill.
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Union Tool Company, Orange, Mass.
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United Cinephone Corp., 43-37 33rd St., Long Island City, N. Y.
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United States Blue Print Paper Co., 207 S. Wabash Ave., Chicago, Ill.
Surveying instruments

United States Gauge Co., 44 Beaver St., New York, N. Y.
Indicating & recording pressure gages

United States Instrument Corp., 19 So. Harrison St., E. Orange, N. J.
Voice powered telephone equipment

United Transformer Corp., 150 Varick St., New York, N. Y.
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Universal Control Devices, 28 N. Loomis St., Chicago, Ill.
Photoelectric equipment

V

Vacutron, Inc., 20 West 22nd St., New York, N. Y.
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Valpey Crystals, P. O. Box 321, Holliston, Mass.
Quartz crystals for frequency control

Van Keuren Co., 12 Copeland St., Watertown, Mass.
Optical comparators & flats

Vapor Recovery Systems Co., 2820 Alameda St., Compton, Calif.
Liquid level indicators

Varney, Gordon, 7475 Melrose Ave., Hollywood, Calif.
Fractional horsepower motors

Vaughn-G. E. Witt Co., 4224 Hollis St., Oakland, Calif
Regulating valves

Veeder-Root, Inc., Sargent & Garden Sts., Hartford, Conn.
Counters, hub odometers

Vergilio Co., J. L., Erie Bldg., Cleveland, Ohio
Liquid meters

Veritas Firing System Co., P. O. Box 974, Trenton, N. J.
Seger cones

Vickers Inc., 1400 Oakman Blvd., Detroit, Mich.
Pumps & valving devices for control of power in oil-hydraulic systems

Victory Equipment Co., 844-50 Folsom St., San Francisco, Calif.
Absolute pressure gages

Viking Instruments Inc., Stamford, Conn.
Tachometers

Visco-Meter Corp., 315 Grote St., Buffalo, N. Y.
Viscosimeter

Voland & Sons, Inc., New Rochelle, N. Y.
Analytical balances & weights

W

Wadsworth Electric Mfg. Co., Inc., Covington, Ky.
Electric time switches

Wagner & Son, Carl H., 1944 N. Albany Ave., Chicago, Ill.
Thermometers

Walker & Co., Geo. T., 324 Fifth Ave., South, Minneapolis, Minn.
Laboratory supplies

Wallace & Tiernan Products, Inc., Belleville, N. J.
Chlorine control & chemical feed devices

Walser Automatic Timer Co., 420 Lexington Ave., New York, N. Y.
Timers

Waltham Dial Gage Co., 85 Myrtle St., Waltham, Mass.
Machinist's dial gages

Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y.
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Warner & Swasey Co., 5701 Carnegie Ave., Cleveland, Ohio
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Warren-Knight Co., 136 N. 12th St., Philadelphia, Pa.
Surveying instruments & equipment

Warren Telechron Co., Ashland, Mass.
Timers & fractional horsepower motors

Water Leak Detector Co., 166 N. Third St., Columbus, Ohio
Water leak detectors

Water Level Controls Co., 765 Hampden Ave., St. Paul, Minn.
Liquid level controls

For addresses, see pages 56-64

Watts Regulator Co., 10 Embankment St., Lawrence, Mass.
Automatic pressure regulating devices
Wayne Automatic Relay Co., 622 Wagner, Fort Wayne, Ind. Photoelectric counters
Weber Bros. Metal Works, 108 N. Jefferson St., Chicago, Ill. Laboratory apparatus
Weber Co., F., 1220 Buttonwood St., Philadelphia, Pa.
Mathematical & surveying instruments
Welch Engineering Service, F. M., Greenville, Ohio
Abrasion testing machines
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago, Ill.
Electrical instruments, vacuum pumps & items for science laboratories.
West & Dodge Thread Gauge Co., Inc., 791 Tremont St., Boston, Mass. Screw thread gages
Western Electro-Mechanical Co. Inc., 300 Broadway, Oakland, Calif.
Load testing devices for a-c. circuits
Western Machinery Co., 306 W. Second St., Wichita, Kansas Laboratory apparatus
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Electrical instruments
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark, N. J.
Switchboard, panel & portable measuring instruments. Industrial & radio test equipment. Light measuring instruments & photographic exposure meters. Also dial type industrial temperature gages, control relays & aircraft instruments.
Westinghouse X-Ray Co. Inc., Long Island City, N. Y.
Industrial x-ray equipment
Wheelco Instruments Co., 1933 So. Halsted St., Chicago, Ill.
Temperature, indicating, recording & control instruments; temperature limit & shut-off device; automatic combustion safeguards
White Co., Inc., David, 315 W. Court St., Milwaukee, Wis. Surveying instruments
White Mfg. Co., 2362 University Ave., St. Paul, Minn. Furnace controls
White-Rodgers Electric Co., 1209 Cass Ave., St. Louis, Mo. Furnace controls
Wilder Sales Co., Drawer 70, Troy, N. Y.
Thermometers
Wilgus Mfg. Co., 1722 East 16th St., Los Angeles, Calif.
Diaphragm operated pressure regulators & combustion control equipment
Wilcolator Co., 17 Nevada St., Newark, N. J.
Thermostats
Wilder Inc., R. S., 26 Bedford St., Waltham, Mass.
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Wilkening Mfg. Co., 1998 S. 71st St., Philadelphia, Pa. Piston ring gages
Wilkens-Anderson Co., 111 N. Canal St., Chicago, Ill. Laboratory supplies
Will Corp., Rochester, N. Y.
Laboratory supplies & apparatus
Williams Apparatus Co., Inc., Herald Bldg., Watertown, N. Y.
Pulp & paper testing equipment & flue gas analysis apparatus
Williams Gauge Co., 1620 Pennsylvania Ave., Pittsburgh, Pa. Water level gages
Willson Products, Inc., Reading, Penna.
Anemometers
Wilson Mechanical Instrument Co., Inc., 383 Concord Ave., New York, N. Y. Hardness testers
Woermann-Schuchhardt, Inc., 17 W. 17th St., New York, N. Y.
Scientific instruments, optics, optical instruments, photographic products, polarizing instruments, precision meters, silent & sound motion picture apparatus
Wollensak Optical Co., 880 Hudson Ave., Rochester, N. Y. Optical instruments
Woods "Lab. Apparatus", F. W., 140-6 Warden St., Pittsburgh, Pa.
Biological laboratory supplies
Worthington Gamon Meter Company, Harrison, N. J.
Liquid meters
Wright-Austin Co., 315 West Woodbridge St., Detroit, Mich. Power specialties
Wyland, George C., Center St., Ramsey, N. J.
X-Ray tubes & cameras

Y

Yarnall-Waring Company, 102 E. Mermaid Ave., Chestnut Hill, Philadelphia, Pa.
Water columns, water gages & blow-off valves for steam boilers, spray nozzles for liquids & hydraulic valves for presses

Z

Zeiss, Inc., Carl, 485 Fifth Ave., New York, N. Y.
Optical instruments
Zenith Electric Co., 603 So. Dearborn St., Chicago, Ill. Magnetic switches, work cycle timers
Zernickow Co., O., 15 Park Row, New York, N. Y.
Tachometers, Tachographs, Tachoscopes, cutmeters, stop watches
Zink Co., John, 4401 South Peoria, Tulsa, Okla.
Straightening vanes for gas, oil & steam lines
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Zuhr, Inc., Henry, 187 Lafayette St., New York N. Y. Laboratory test instruments

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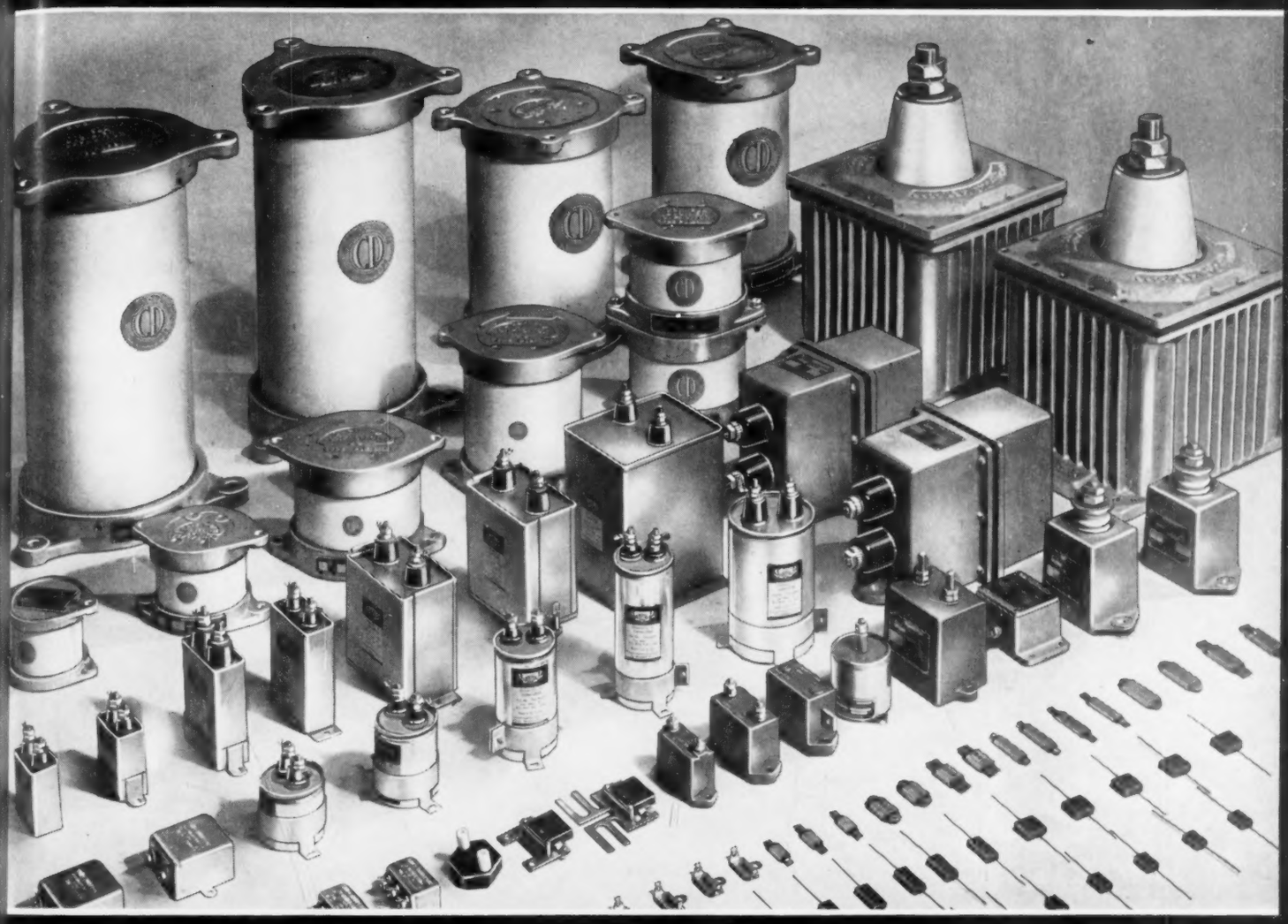

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